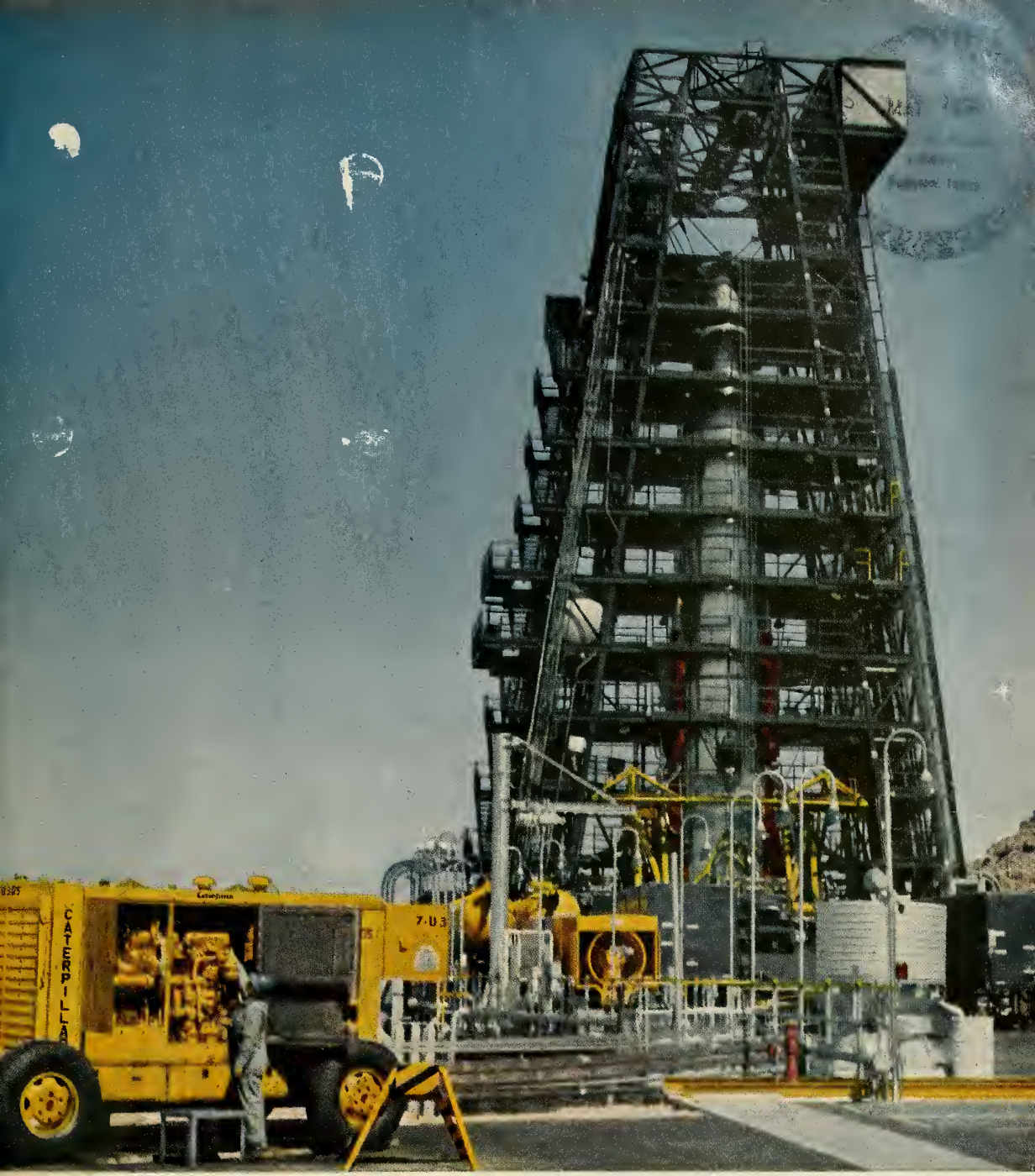


missiles and rockets

INCLUDING MISSILE ELECTRONICS

MAGAZINE OF WORLD ASTRONAUTICS

This Issue: **SUBSYSTEMS AND COMPONENTS**

MAY, 1958

Friendly Foe

When a new air defense missile is produced, its "kill accuracy" is theoretical until it is tested against a realistic target under operational conditions. The new, supersonic missile target, **USAF XQ-4,** is one of many "friendly foes" developed by Radioplane to simulate various air enemy threats.

Duplicating the performance and radar appearance of a supersonic, high-altitude bomber, the radar-controlled XQ-4 is designed to test the seek-and-kill ability of air defense systems and their missiles.

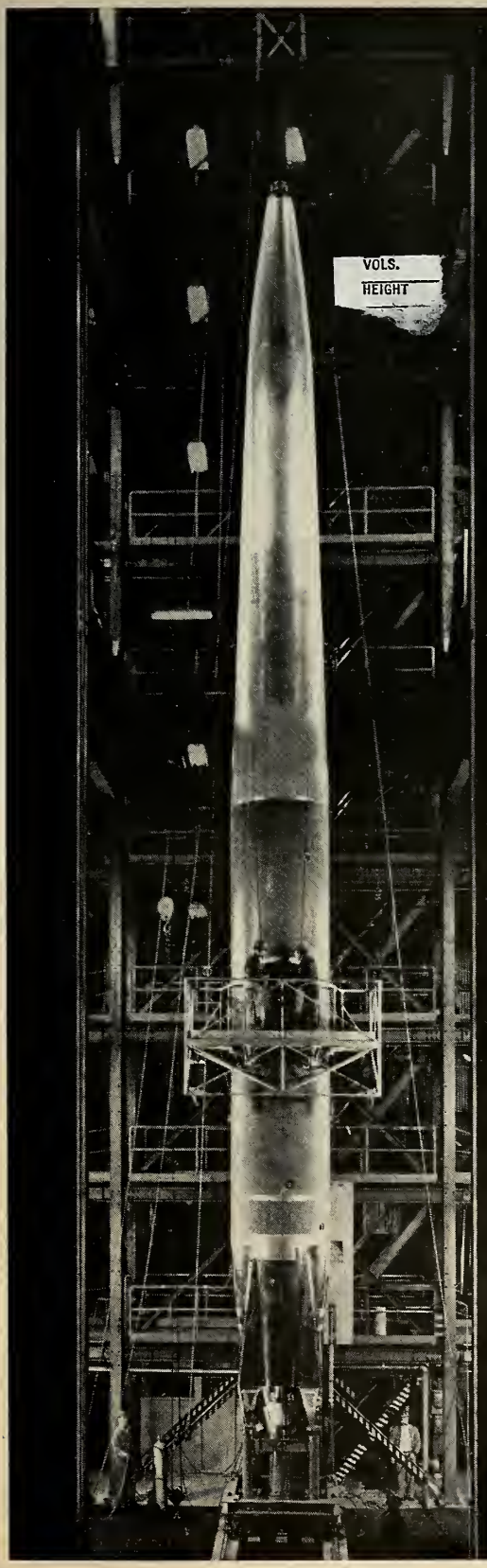
As major advancements have been made in U.S. Armed Forces air defense weapon systems, Radioplane has designed and developed targets compatible with the missions of these weapons. The XQ-4, for example, not only imitates invading bombers, but tallies up the score of hits and misses when fired upon.

Radioplane, the first to produce remotely controlled target aircraft, maintains dynamic research programs to seek low-cost solutions for tomorrow's defense problems.

Radioplane

A Division of Northrop Aircraft, Inc.

VAN NUYS, CALIFORNIA, AND EL PASO, TEXAS



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The upshot of this is that we can handle any project from far-out basic research to static and dynamic testing of complete airframes.

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We're completely qualified to work with any kind of metals or nonmetals; materials and processes; electrical, hydraulic and pneumatic components and systems; structures; reliability; environmental testing (including re-entry); and instrumentation.

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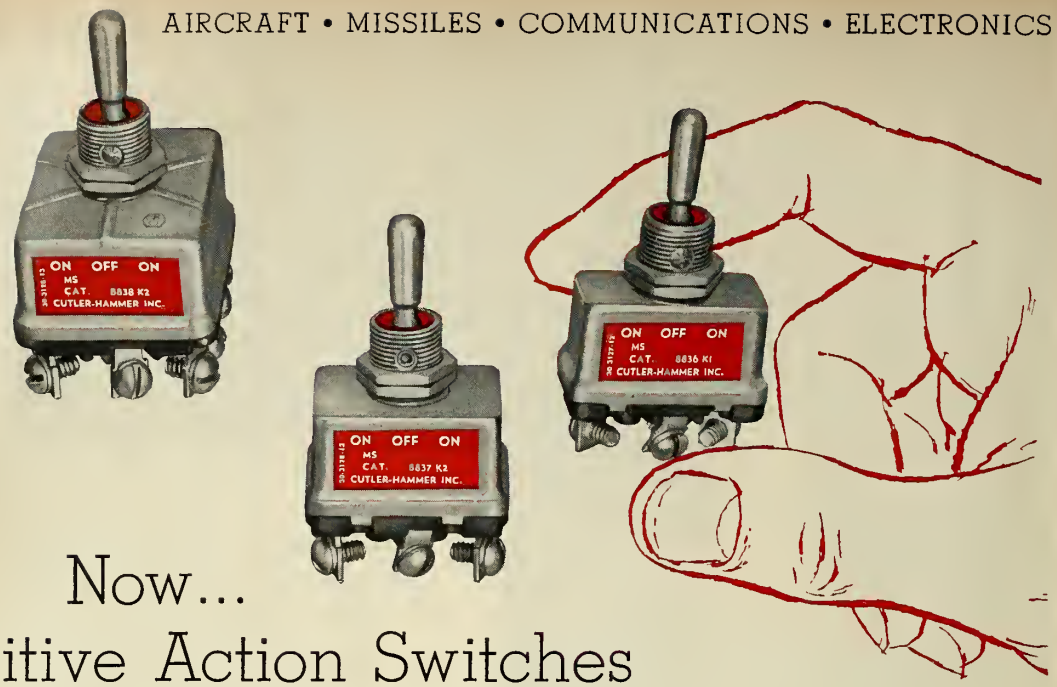
Please write to E. R. Schenkel, Missile Division Test Lab Manager, North American Aviation, 12214 Lakewood Blvd., Downey, Calif.

MISSILE DEVELOPMENT DIVISION

North American Aviation, Inc.



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missiles and rockets

Magazine of World Astronautics

1001 Vermont Ave., N.W., Washington 5, D.C. Tel. STerling 3-5400

missiles and rockets Vol. 3, No. 6, May, 1958

Published every month by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D.C. Printed at the Telegraph Press, Harrisburg, Pa.

Executive, Editorial, Circulation Offices: 1001 Vermont Ave., N.W., Washington, D.C. WAYNE W. PARRISH, President & Publisher; LEONARD EISERER, General Manager; C. A. HURT, Assistant Publisher; LAWRENCE BRETTNER, Circulation Director.

Subscription rates: U.S. and Canada—1 year, $8.00; 2 years, $12.00; 3 years, $14.00. Foreign—1 year, $9.00; 2 years, $14.00; 3 years, $17.00. Single copy rate—$.75. Subscriptions are solicited only from persons with identifiable commercial or professional interests in missiles and rockets. All subscription orders and changes of address should be referred to: GENEVA C. KINNAIRD, circulation fulfillment manager. Second class mail privileges authorized at Washington, D.C., with additional entry at Harrisburg. Copyright 1958, American Aviation Publications, Inc.

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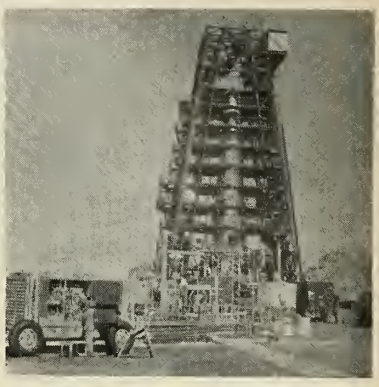
this issue: Missile Components and Subsystems

news and trends

special features

next issue: Missile Optics and Telemetry

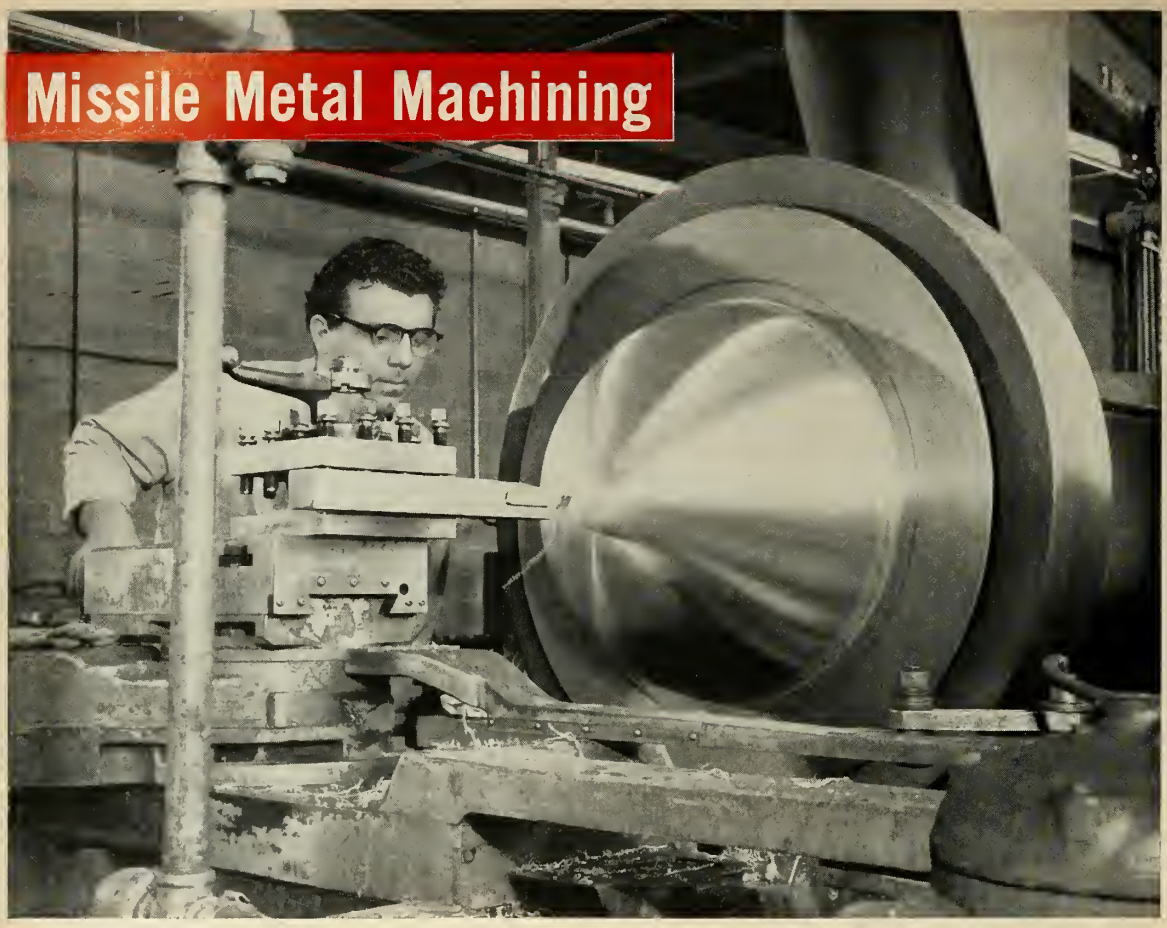
cover picture:



Representing the tremendous amount of ground support equipment necessary for testing ICBMs, the above photograph shows an Atlas *set up for static firing of its main and vernier engines at Convair-Astronautics' Sycamore Canyon facility in California. Independent ground power units, such as Caterpillar Tractor Co.'s diesel electric generator (at left), propellant transfer facilities, and transportable vans for electronic equipment, are all big procurement subsystem items.* *(See Page 78.)*

columns

departments



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Thank you, Dr. Hagen!

The missile business is not a mass production industry. Missiles for tomorrow aren't skinned, ribbed, and riveted like flying machines —they are machined, welded, and heat treated, and although we spend billions for such missiles, most of the money goes for painstaking research, for prototype development—and for quality. This is accomplished—not by machines—but by the men behind the machines, and by the brains, vigor and confidence of these men.

Dr. John P. Hagen, for one, has set an example through public appearances, through testimony before Congress, and through eager work in his own shop. He has shown what is needed to push the American missile business forward. Thank you, Dr. Hagen! Thank you for being yourself.

Men like Dr. Hagen certainly do not necessarily come from the aircraft industry—or from the automobile industry—or from an Army arsenal or a Navy shipyard. They come from all walks of the great American industry—to make up a special segment: the $4 billion missile business.

In rocketry, more than in any other science, there is a definite requirement for an individualistic approach to all problems. You don't build rockets—like guns or aircraft—by the book.

The successful completion of a rocket system program requires a mass of minute, nerve-wracking detail work. Yet, the essence of rocket progress is foresight and common sense, exhibited by individuals without any fear or reluctance to back a program all the way, with their personality, optimism and spirit.

Our confused rocket programs need this kind of push. Technological progress in this country—despite our great arsenal of scientific talent —is suffering from lack of individualism, lack of encouragement for young engineers to stick their necks out, and lack of individual recognition.

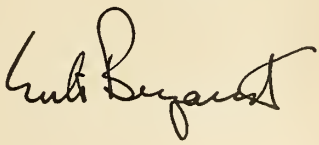
Let us not fool ourselves and think for a moment that we shall catch up with Russia in rocketry by asking our able missile men to keep their mouths shut, to make them sterile to individualistic thinking and to common sense. What's happening to the great American democracy? Is individualism on the wane in this country? If so, missile and rocket progress most certainly will go down with it.

The individualistic approaches by Dr. Wernher von Braun, Maj. Gen. B. A. Schriever, Maj. Gen. John B. Medaris, Rear Admiral Raborn and Dr. John P. Hagen—the opinions of whom have been fairly unsuppressed until now—have at least carried our missile programs forward to some degree.

But we need thousands of such men, engineers and scientists who—like Dr. John P. Hagen will press their teams on to perform a remarkable job through personal sacrifice and personal interest—through completely uninhibited thinking and a truly democratic individualistic approach.

Dr. Hagen could not have put his satellites up alone. His success is based on teamwork. So is von Braun's and Admiral Raborn's and General Schriever's. Teamwork alone, however, would have resulted in little or nothing; excellent leadership is a must in this business.

We have done fairly well in recent years thanks to this handful of individualists and their personal sacrifices. But we need to do better—we need many, many more of them—people with individualistic courage and skill, applied right across the board. We must encourage our young scientists and engineers and inventors to exhibit the same kind of guts and go—and not kill the drive in them.



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NEW TWIST FOR JET TURBINE SHAFTS

Formerly many of these shafts were made from upset tubing. Almost any design engineer, production man or purchasing agent would say — this is it. But not the people in our forging department. They are always anxious to try for a better solution — a new twist — to even a simple problem.

As a result, Cameron now produces these shafts from specified billet stock in a one piece forged unit. The head is formed and the tube is extruded in a single operation. Metallurgy can be accurately controlled by our own high quality alloy steel production. Grain structure is perfect and the price, which has taken an interesting turn, is even lower than for the upset method.

Ferrous forgings from 8 lbs. to 8,000 lbs. in unusual shapes and in alloys for extreme service are our specialty. Cameron's split-die forging presses (largest in the world) have solved many problems in this field. For simpler shapes such as this jet turbine shaft, other Cameron presses are also adding a new, money saving twist to old techniques. Write, call or come by . . .

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when and where

MAY

American Society of Tool Engineers, Second Annual Technical Meeting, New York, N.Y., May 1-8.

National Flight Test Instrumentation Symposium, Instrument Society of America, Park Sheraton Hotel, New York, N.Y., May 4-7.

Professional Group on Microwave Theory and Techniques, National Symposium, Stanford University, Palo Alto, Calif., May 5-7.

IRE, ACM, AIEE, Western Joint Computer Conference, Los Angeles, Calif., May 6-9.

IRE, National Conference on Aeronautical Electronics, Biltmore Hotel, Dayton, Ohio, May 12-14.

IAS, National Midwestern Meeting on Guided Missiles, Hotel Chase, St. Louis, Mo., May 12-14.

3rd Production Exhibitions Conference, Institute of Production Engineers, London, England, May 12-21.

Society-Experimental Stress Analysis 1958 National Spring Meeting, Manger Hotel, Cleveland, Ohio, May 14-16.

Armed Forces Day Dinner, Sheraton-Park Hotel, Washington, D.C., May 16. Observances in various cities, May 10-18.

17th Annual National Conference, Society of Aeronautical Weight Engineers, Inc., Belmont Plaza Hotel, New York, N.Y., May 19-22.

AIA, Board of Governors Meeting, Williamsburg, Va., May 21-23.

Aviation Writers Association Annual Convention, Shamrock Hilton Hotel, Houston, Texas, May 25-31.

JUNE

IAS, AIEE, ISA, National Telemetering Conference, Lord Baltimore Hotel, Baltimore, Md., June 2-4.

First National Guided Missile Industry Conference, Mayflower Hotel, Washington, D.C., June 4-6 (Robert H. Goddard Memorial Dinner, June 6).

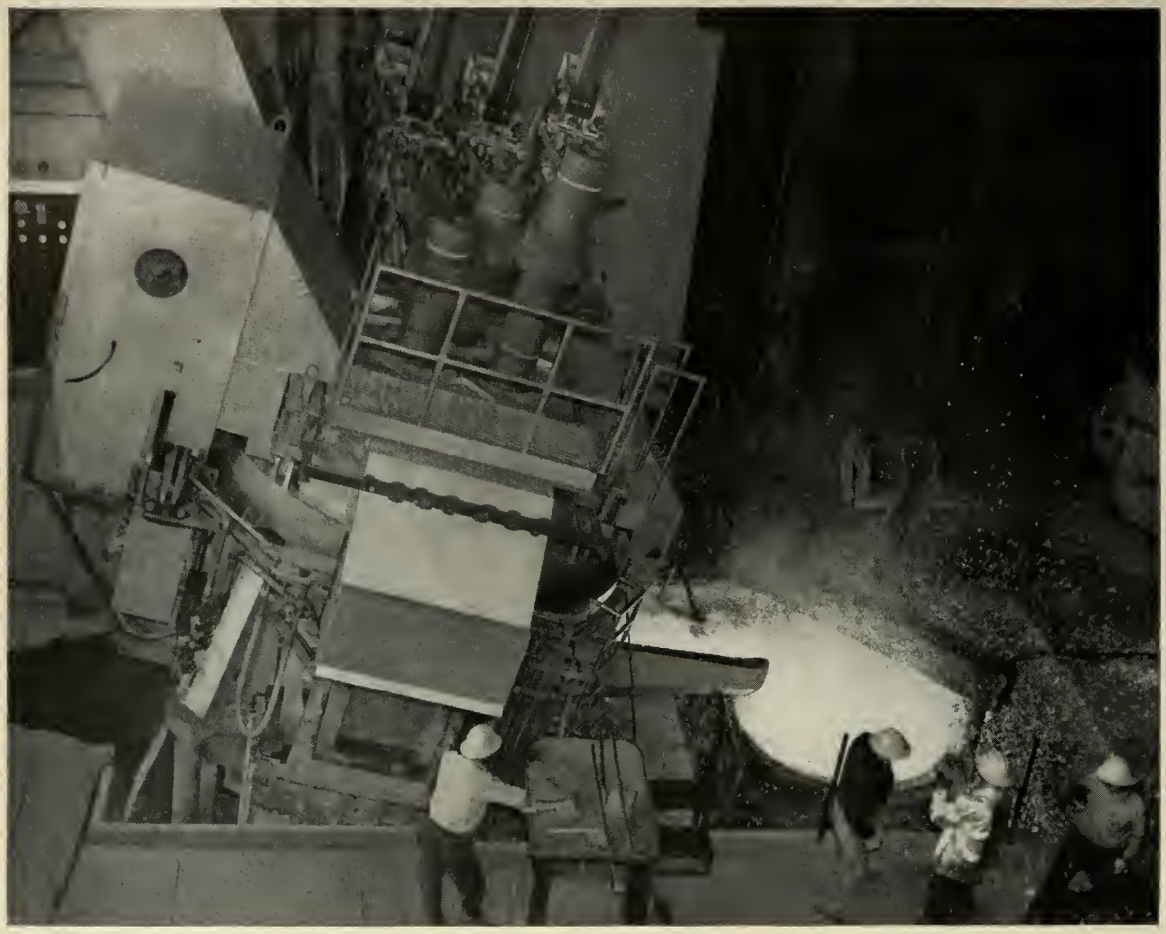
Armed Forces Communications and Electronics Association Convention, Sheraton-Carlton Hotel, Washington, D.C., June 4-6.

IRE Second National Symposium on Production Techniques, Hotel New Yorker, New York, N.Y., June 5-6.

American Rocket Society, Semiannual Meeting, Hotel Statler, Los Angeles, Calif., June 8-11.

ASME Semiannual Meeting, Statler Hotel, Detroit, Mich., June 15-19.

Military Electronics, National Convention, Sheraton Park Hotel, Washington, D.C., June 16-18.



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Life Span 10 Years

To the Editor:

We were quite pleased with the handling of our article on recoverable booster studies to cut manned space flight cost in the April issue. However, we were somewhat concerned with regard to a couple of typographical errors which occurred.

Of particular concern to us was the one giving operational life span of a given model as 100 years, which should, of course, have been 10 years. We believe that most of your readers will recognize this as a typographical error, but are concerned with the possibility that some might not. The only other error was the interchange of numbers on Figures 1 and 2.

D. C. Romick
Weapons Systems, Department 460
Goodyear Aircraft Corporation

GS Group Needed?

To the Editor:

After reading the Ground Support Equipment issue of m/r for January, 1958, I began to wonder why an organization of GSE Engineers had never been formed.

With the increase in importance and in government expenditures on GSE for advanced weapons systems, it would seem that a group of this sort could do much in helping to standardize techniques and methods, and to disseminate information among manufacturers who would not normally come into contact with each other.

I would welcome any comments on this subject from m/r readers who may or may not be actively concerned with GSE.

Walter E. Bailey
Bell Aircraft Corp.
Buffalo 5, N.Y.

An excellent suggestion—we too, would welcome any comments from our readers—Ed.

Hi Temp Omission

To the Editor:

We have read with great interest and enthusiasm the very extensive review of missiles in the March issue. It was an outstanding piece of work.

However, there was one omission which is most important to us: in the materials section no mention was made of the very extensive line of high-temperature materials of construction made by Haveg Industries, Inc., and Reinhold Engineering and Plastics Co., Inc., for use in blast tubes, nozzles, jet vanes, jetevaters, insulation, adapters, and the like.

These materials, known under the proprietary names of Missileon, Mercuron, Planeton, Rocketon, Orbiton, Asteron, Galaxon, etc., are now standard in 18 different missile programs, many of which are in production.

We are also working in nose cone and re-entry areas and have equipment in place to make any sizes up to 12 feet in diameter. We are also doing an extensive amount of both prototype and production work at both Haveg and Reinhold facilities.

We are also manufacturing a wide variety of high-temperature wire and cable for the electronic phases of the industry. This includes Teflon coated wire and wires coated with pure silica fiber.

Haveg materials have functioned satisfactorily when subjected to products of combustion having flame temperatures as high as 5800°F. Past experience indicates that we should be in a position to cope with all high-temperature insulating problems associated with the missile field.

John H. Lux
President
Haveg Industries, Inc.
Wilmington 8, Del.

GE Did its Job

To the Editor:

I have recently read an article in the March '58 issue of m/r. describing the General Electric engine on the *Vanguard* program.

I have been gathering certain facts from the people in my organization on the subject of engine performance and thought it would be worthwhile to present a summary of this information to you. Your story mentioned that, according to one Pentagon source, the Hermes engine proved to be—among other things—too rusted for use in the first-stage vehicle; GE has to design a new first stage engine for the application of the Vanguard.

In my experience, no one engine has ever filled the bill for another application without design changes. This was exactly the case of the Vanguard engine designed by the GE Co. The experience gained during the Hermes Program was directly applicable and has largely contributed to a compressed development time.

MISSILES and ROCKETS continues: "As for the *Vanguard,* in spite of official reasons released to the public, the general opinion is that it has not

NO GETTING AWAY FROM IT!

Here's the Army's answer to a major problem in U. S. defense. Hawk, recently-revealed missile, hunts and destroys invading aircraft *even at tree-top altitudes!*

Raytheon radars of unique design give Hawk its amazing low-level ability in the blind zone of conventional radars.

This aptly named 16-foot missile can be launched from fixed installations for the defense of U. S. cities. Highly mobile, Hawk can also travel with fast-moving land forces of the Army and Marine Corps, or be transported by helicopter or plane.

Raytheon, with more than a decade of pioneering in guided missiles, is prime contractor for the complete Hawk weapon system.

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Missiles/Rockets—and Steel

Lukens Steel Company, with the world's largest capacity for producing spun and pressed "head" shapes, is forming nose cone blanks for the Air Force's Thor and Atlas, as well as other vital rocket and missile parts.

In the past, the men who carried the major burden in developing weapons systems had little need to know about the techniques for forming steel plate and other heavy materials. But now such problems are a vital part of our missile age, and steel companies having the necessary facilities and know-how are playing an important role in missile weapon systems development.

That is why, for example, the nose cone blanks for the Air Force's Atlas and Thor ballistic missiles are being formed by Lukens Steel Company on one of the most unusual facilities in the steel industry—a mammoth four-post hydraulic press capable of exerting a force of up to 4 million pounds. Lukens is performing this work for General Electric Company's Missile and Ordnance Systems Department, prime contractor for the ballistic nose cone.

Over Seventy-Five Years of Experience

Lukens produces its own steel and possesses the world's largest capacity for spinning and pressing the dome shapes known to the steel industry as "heads." In 1880, Lukens pioneered a machine which produced steel heads by means of a spinning or flanging operation—similar in working principle to a potter's wheel. Since that time, this process has undergone constant refinement. Today, supplemented by a line of presses for volume production items, Lukens facilities offer the widest range of types, sizes and qualities of head shapes available anywhere. The versatile flanging machines can spin heads from 12 inches to 21 feet in diameter and from 3/16 inch to 6½ inches in thickness. Huge hydraulic presses, like the one used for the Air Force program, have turned out the largest heads pressed—hemispheres nearly 7 inches thick. These same machines can press ultra-high strength steel in sheet gages to the order of 180,000 psi tensile material.

The metals used in head production range from the various steels and clad steels rolled on Lukens own mills to such materials as aluminum, copper, nickel, stainless steel, Monel, Inconel, titanium and Hastelloy.

For Missile Production and Handling

As the long-time leader in producing heads, Lukens has served many fields of industry—the most recent being the nation's missile producers. The areas connected with missile production and handling in which head shapes are playing a growing role are often areas in which Lukens heads have been employed in similar manner for many years. The storage of fuels and oxidants at test and launching sites requires tanks with heads at each end. Formed from corrosion-resistant Lukens clad steels, heads have long been supplied to the chemical industry for precisely such application. Solid rocket engine casings utilize dome ends which must withstand enormous pressures. Both the petroleum and chemical industries use steel heads for vessels in which liquids are contained under high pressures. To meet the demands of absolute safety, Lukens has spent years working with the latest high-strength steels and perfecting the required precision. This skill and knowledge is immediately available to missile engineers to fulfill their own design requirements.

On this mammoth hydraulic press capable of exerting up to 4 million pounds pressure, Lukens Steel Company has formed nose cone blanks for the Air Force's Atlas and Thor ballistic missiles.

Nose cones, fuel tanks, and rocket casings are, of course, only a few of the literally hundreds of uses to which heads can be put. In using them as examples our point has simply been this: wherever a metal dome shape can be utilized in the missile industry, experienced craftsmen can provide it—swiftly, accurately, with a quality achieved through long experience.

Send for More Information

Lukens specialized knowledge of head uses, sizes, types and qualities is immediately available. For assistance with specification or production problems, write to Manager, Marketing Service, Lukens Steel Company, 150 Lukens Building, Coatesville, Pennsylvania.

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Circle No. 93 on Subscriber Service Card.

. . . letters

flown mainly because of an inadequate first-stage engine."

The facts are that GE delivered all engines to the Martin Corp., and that all engines passed acceptance tests without failure. As a matter of facts, qualification tests were successfully completed without waivers.

Your next paragraph mentioned the cause of the *Vanguard* failure, after the missile attained an altitude of 96".

Detailed investigation by qualified personnel revealed that raw fuel leaked out of propellant pipes upstream of the GE engine and that neither design, maintenance, or operational deficiencies of the GE engine contributed to this failure.

Finally, your statement "The *Vanguard* finally struggled into the sky, and the marginal thrust-to-weight first-stage engine got the *Vanguard* off the ground" are matters no engine contractor has control over. Engines are built to specifications of thrust ratings, specific and total impulses which have to lift a given weight into the air. The specifications given to the GE Co. were met in all aspects.

Richard F. Gompertz
Malta Test Station
Ballston Spa, NY

Wrong Picture

To the Editor:

The nice editorial treatment you gave to the story on DuKane Corp'. development of a new satellite transmitter (April, page 152) was extremely gratifying both to DuKane and to us, as DuKane's public relations counsel. We have already heard from readers of m/r who want more information, even though the issue has been out only a few days.

Apparently, however, someone mixed up DuKane's photographs with

someone else's, for the photos which appeared in connection with the satellite transmitter story were not those originally supplied, and bore no relationship to the text of the story or the picture captions as published.

These slip-ups occasionally occur, I know, in the pressure of getting out a periodical publication. In fairness to readers of m/r who have an active interest in the subject, however, I presume you'll want to print a correction of this one, and possibly include the right pictures in your next issue.

Robert E. Kilbride
The John Marshall Ziv Organization
75 East Wacker Drive
Chicago 1, Ill.

For correct photo, see p. 19—Ed.

Recommended Reading

To the Editor:

We read, with great interest, your excellent article entitled "1958 Missile Materials Review" in the March issue. In this regard, we believe that you will be interested in the enclosed report which has just been published by the AIA under the auspices of our Aircraft Research and Testing Committee and Manufacturing Committee.

This report is prepared annually to provide suitable information for the guidance of research and development programs conducted by the Department of Defense, the aircraft and missile industry, and materials producers. Copies are available upon request to this office. Your comments will be welcomed.

H. D. Moran
Technical Service
Aircraft Industries Association
Los Angeles 36, Calif.

We heartily recommend this report to our readers who are engaged in the nation's missile research and development programs. This report briefly, but concisely, surveys the requirements for materials, processes, testing and manufacturing methods forecast for the next five- and ten-year periods . . . Ed.

Earlier *Explorers*

To the Editor:

In view of the recent feats of the Jupiter-C rockets that carried *Explorer* I, II, and III into space, the following may be of interest:

The original *Explorer* I was, in its day, the largest free-flight balloon ever built. On July 28, 1934, after being filled with hydrogen, it was released over the Dakotas carrying a crew of three Army Air Corps officers. The balloon rose to an altitude of 11½ miles before it suddenly tore open across the bottom and carried its crew to an altitude of one-half mile before they jumped to safety.

About a year later, *Explorer* II, an even larger free-flight balloon, was ready for another attempt to send instruments and observers to the top of the earth's atmosphere. It rose to an officially-recognized height of 72,395 feet, carrying two of the previous crew members and 64 scientific instruments. These flights, jointly sponsored by the National Geographic Society and the Army, yielded invaluable data on the stratosphere and other phenomena. The two crew members, Capts. Albert W. Stevens and Orvil A. Anderson, spent one hour and forty minutes above seventy-thousand feet.

Windsor P. Booth
National Geographic Society

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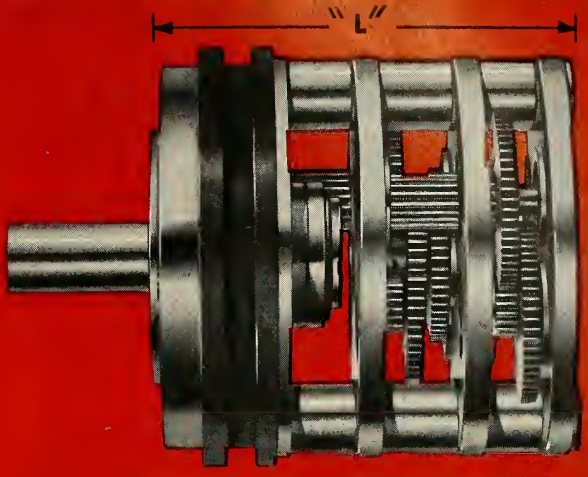
- Mount directly on all Edison and Bureau of Ordnance Motors without adapters.
- Adapters available to mount on any motor.



CHARACTERISTICS	STANDARD EDISON GEAR HEADS									
Size	8		10		11		15		18	
Part Number										
Pinion Data: Number of Teeth	12		13		13		15		15	
Diametral Pitch	120		120		120		96		96	
Pressure Angle	20°		20°		20°		20°		20°	
Pitch Diameter	.1050" +.0 −.0005		.1083" +.0 −.0005		.1083" +.0 −.0005		.1562" +.0 −.0005		.1562" +.0 −.0005	
Gear Ratio to Length "L"	Ratio	"L"	Ratio		"L"	Ratio	Ratio	"L"	Ratio	
	17	0.750	31		0.781	36	40	0.812	60	
	42	0.812	93		0.954	108	140	1.000	240	
	104	1.008	280		1.054	324	490	1.100	960	
	253	1.070	840		1.116	972	1715	1.162	3840	
	615	1.204	2521		1.266	2916	6000	1.328	15,360	
	1494	1.347	7565		1.409	8748	21,000	1.487	61,440	
	3629	1.421	22,696		1.500	26,244	73,500	1.600	245,760	
Moment of Inertia GM CM²	.01		.018		.02		.05		.08	
Maximum Running Torque in. oz.	15		15		20		25		25	
Maximum Stall Torque in. oz.	15		35		40		50		50	
Breakdown Torque in. oz.	.01		.01		.012		.015		.018	
Backlash maximum	30′		30′		30′		30′		30′	

Gear Tolerances: Precision Class 2 AGMA 236.02. *Bearings:* Stainless Steel ABEC Class 5 or better. *Shaft Radial Play:* .002"/inch length max. with 4 ounce gage load. *Shaft End Play:* .002" max. with 1 pound gage load. Friction Slip Clutch available on request. Designed to meet applicable paragraphs of MIL-E-5272.

Thomas A. Edison Industries
INSTRUMENT DIVISION
85 LAKESIDE AVENUE, WEST ORANGE, N. J.

McGRAW EDISON

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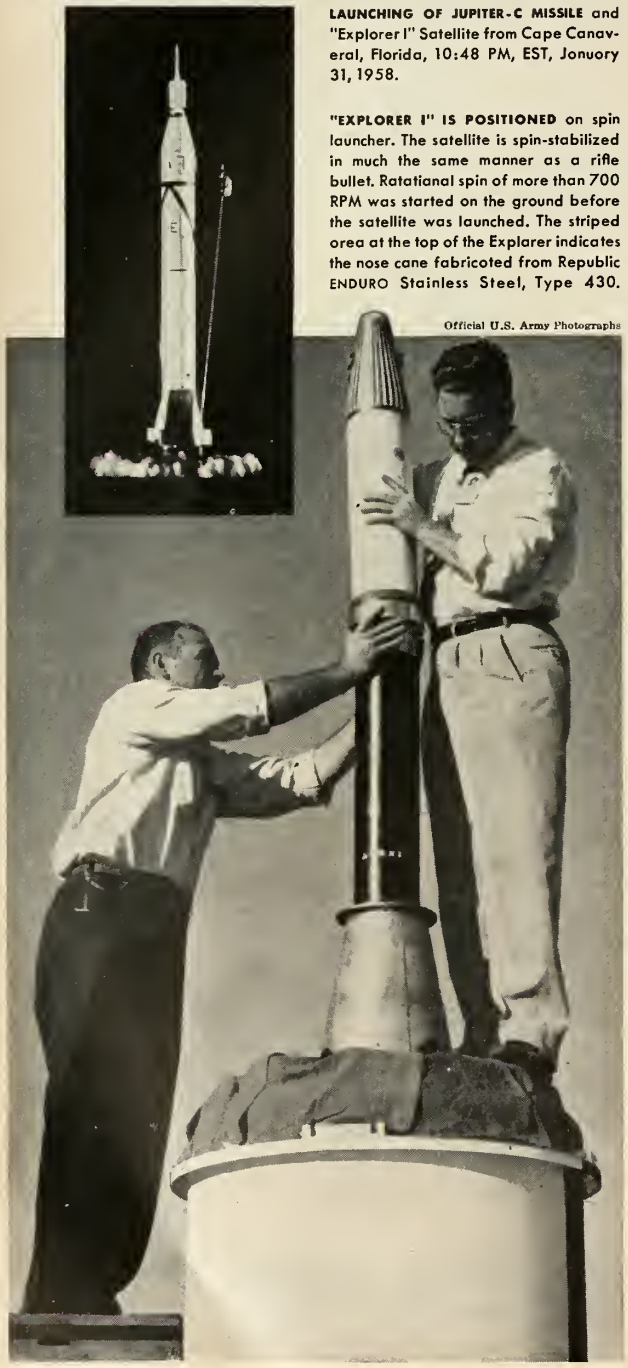
World Circling Explorer 1 is Tipped with Republic Stainless Steel



LAUNCHING OF JUPITER-C MISSILE and "Explorer I" Satellite from Cape Canaveral, Florida, 10:48 PM, EST, Jonuory 31, 1958.

"EXPLORER I" IS POSITIONED on spin launcher. The satellite is spin-stabilized in much the same manner as a rifle bullet. Ratational spin of more than 700 RPM was started on the ground before the satellite was launched. The striped orea at the top of the Explorer indicates the nose cone fabricoted from Republic ENDURO Stainless Steel, Type 430.

Official U.S. Army Photographs

Vital instruments in the nose section of the U. S. Army satellite, "Explorer I", are protected by a cone of ENDURO® Stainless Steel produced by Republic. The nose cone was fabricated from Type 430 by The Lodge and Shipley Company, Cincinnati, Ohio using the Floturn Process.

Type 430 is highly ductile. It is readily formed into desired shapes by cold-forming, drawing, and bending operations. It provides low thermal expansion and is highly resistant to atmospheric corrosion, erosion, and oxidation at high temperatures.

As rapid developments in the fields of missiles and rockets increase demand for these high-strength, select formula steels, Republic is keeping pace through research and new production facilities.

Our metallurgists and engineers are always available, without obligation, to work with your personnel in using Republic Stainless Steels, Heat-Resisting Steels, Alloy Steels, and Titanium to best advantage. Check and mail the coupon if you would like a Republic specialist to call at your plant.

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contract report

Trends

Don't be dismayed at the raft of contracts being placed now through fiscal year 1958 (ending June 30), and the fact that you don't appear to be getting your share. A considerable share of the contracts to be negotiated and actually signed during these last two months have already been arranged in advance by contract letters or letters of intent. A large percentage of funds have already been committed this way, due to the fact that it was physically impossible to negotiate contracts at the rate that requirements called for them.

In this connection, obligation of Defense Department funds for major procurement and production hit a two year high of $2.4-billion during the month of March—with AF obligating $1.7-billion; Navy, $400-million; and Army, $300-million. This brings the total for the January-March quarter to $5.4-billion.

Cooperation between Convair-Astronautics division of General Dynamics and AVCO Manufacturing Corp.'s AVCO Research Laboratory on a minimal manned satellite may be a significant sign of things to come. Space flight proposals are one thing. Space flight performance is another. It's a very expensive proposition, and money is a function of effort—scientific, technological and industrial.

To do the space flight jobs in the short time allowed by Soviet competition will require massive effort. This, in turn, means large industrial capabilities devoted to this one subject. Thus, it may be natural to expect project mergers among two or more large corporations. This means that it's more important than ever for you to cement your relations with procurement officers of some of the larger companies in the field.

Pentagon reorganization—No matter whose plan gets the nod—it will not have any immediate effect on contract procedures—at least, not directly. Ultimately, it may have a major impact on which Service gets the most money; and on how much information is or is not made available to contractors. Greater centralization of power in the Secretary of Defense, as proposed by the President, could make it easier for one ambitious Service to grab the lion's share of the funds.

The reason for this is—the plan will mean that fewer people will have to be sold in order for any one Service to get its way, or even to place one of its own ardent proponents in the key spot. This is one of the worries of House Armed Services Committee Chairman Carl Vinson. Another worry is that centralization of all military information services under one absolute czar will mean more censorship than exists even now—not only for the press but for industry as well. It could mean, for example, that you might have to have a "need to know if you need to know . . ."

Here and there: Defense Department has abolished its Research and Engineering Coordinating Committee on Guided Missiles, saying it had served its purpose . . . Navy's asking for $44.2-million for *Talos* in fiscal year 1959, up from $27.6-million in 1958 . . . Army's letting of *Pershing* prime systems contract to The Martin Company means anyone wanting business on this project should work on Martin's Orlando division. . . . Anyone with ideas about really large thin-wall casings should get in touch with Thiokol Chemical Corp. They are already statically firing solid propellant motors 10 feet in diameter by 25-to-30 feet long.

Awards

By Navy: Philco Corp., received $15 million for production of Sidewinder guided missiles. Light Military Electronic Equipment Department of GE Electric Co. received $10 million for production of Sidewinder guided missiles.

By Navy Purchasing Office: Minneapolis-Honeywell Regulator Co., Davies Laboratories Div., received $70,240 for magnetic tape loop analysis system.

By Navy, Bureau of Ordnance: The New Mexico State College was awarded $152,366 for eighty assembled POGO-HI targets. Westinghouse Electric Corp. received $132,000 for facilities to produce *Polaris* launching system. General Electric Co., received $163,409 for studies leading to the development of ultra-high steels. Vitro Laboratories, Div. of Vitro Corp., received $107,155 for engineering to integrate components of the Terrier land weapon system.

By Navy, Bureau of Ships: Norden-Ketay Corp., Instrument and Systems Div., received $1,119,860 for various switchboards.

By Navy, Office of Naval Research: Materials Research Corp. received $25,500 for research on structural changes of age-hardening processes in binary alloys. Mass. Institute of Technology received $25,000 for research on thermoaeroelastic modeling. University of California received $146,845 for research on the basic factors affecting the strength of metals. Arthur D. Little, Inc., received $65,000 for a study to determine a basis for the decision as to proper level of support of fundamental research. Cooper Development Corp. received $185,758 for research involving measuring portions of the electromagnetic spectrum during a total solar eclipse.

By Your District Public Works Officer: McDonough Construction Co. of Florida, received $763,376 for Azusa radar facility at Eleuthera AFB. McDonough Construction Co. of Florida received $273,833 for radar facility at San Salvador, Mayaguana and Grand Turk Islands, British West Indies.

By U.S. Air Force: General Electric Company's Aircraft Gas Turbine Division received $17-million for an advanced product improvement program on the J79 jet engine.

BY AFFTC, Air Research and Development Command: P. J. Walker Co. was awarded $318,924 for construction of X-15 test facility. Petersen Construction Corp. received $53,358 for mechanical and electrical system for support of 10000 PSI nitrogen system.

By AFMDC, Air Research and Development Command: Stanford Research Institute was awarded $90,468 for study of sled slipper wear problems. Remington Rand Univac received $94,586 for uniservo tape recorder and play back units and spare parts.

HQ AFMTC Air Research and Development Command: Collins Radio Co. received $187,600 for modification kits for AN/FRW-2 transmitter. Missileonics, Inc. received $69-656 for station, mobile and interference analysis. Westvaco Chlor-Alkali Division of Food Machinery and Chemical Corp. was awarded $37,873 for rocket propellant. Midwestern Instruments received $38,565 for recorders and galvanometers. Dynatronics, Inc. received $52,035 for 200-volt D.C. power equipment. Coleman Engineering Co., Inc. received $28,014 for gaertner digitizing kit. General Dynamics Corp. received $102,716 for test equipment.

By HQ Dayton Air Force Depot: Raytheon Mfg. Co., Government Relations Division, received $1,108,000 for countermeasures sets. **By HQ Rome Air Force Depot:** Flight Research, Inc. received $35,764 for flight research multidata, synchronous motion picture camera.

By HQ AFOSR: The Board of Trustees of the Leland Stanford Jr. University received $90,000 for research on "microwave solar

. . . contracts

radiation." The Kentucky Research Foundation received $26,136 for research on "chemistry of N-Sulfinyl Amines." Massachusetts General Hospital received $100,000 for research on "Study of Behavior and Performance." Purdue Research Foundation received $27,500 for research and reports concerning "The Reactions of Amident Anions." Polytechnic Institute of Brooklyn received $33,333 for research on "Electron Flow in Plasmas and High Density Bemas." Stanford Research Institute received $43,339 for research on "Luminescence of Solids Produced by Surface recombination of Atoms." Giannini Research Laboratory received $34,887 for studies on ferromagnetic rare earth systems. Alfred University received $29,918 for a study of the correlation between the defect solid state and catalysis. The University of North Carolina received $25,566 for research on "Metal Ion Interaction with 'Chelons'". Bolt, Beranek and Newman, Inc. received $58,505 for research and reports concerning "Organizational Characteristics of Man-Machine Systems." The Trustees of Columbia University received $47,008 for research on "Chemical Bond Energies." Rutgers State University received $36,183 for research on a study of "Properties of Matter by Means of Nuclear Magnetic Resonance Techniques." The Regents of the University of Minnesota received $56,000 for research on the study of "Natural and Induced Spectra of Some Ferrites." Kentucky Research Foundation received $27,910 for research on the electrical and liquid-solid transformation properties of systems of the group Va and VIa elements. Reaction Motors, Inc. received $44,332 for research on the influence of ions on rocket combustion. The University of Pittsburgh received $40,300 for research on antiferromagnetic resonance, paramagnetic resonance in phophors, foreign atoms in silver halides and nuclear resonance. Giannini Research Laboratory received $98,450 for study of plasma jets; $97,627 for investigation of electric thrust devices. Aerojet-General Corp. received $48,056 for research on "Kinetics of Solid Phase Reactions." New York University was awarded $25,755 for research on hydrodynamic equations for a free radical flame. Brown University received $33,275 for research on "Theoretical Study of Problems of Compressible Flow." The University of Chicago received $118,950 for research on "Nuclear Interactions in Cosmic Radiation." Giannini Research Laboratory received $98,025 for basic study of energy exchange process between an electric arc and a gas flow. Allied Research Associates, Inc. received $39,958 for research and reports concerning "Melting and Aerodynamic Ablation of Metals."

By HQ ARDC, Cambridge Research Center: Aerojet-General Corp., $387,730 for aerobee rocket. The Ramo-Wooldridge Corp. received $29,302 for research in the study of infrared sky backgrounds by techniques of space filtering. Geo-Science Inc. received $94,710 for research in the study of air glow and atmospheric reactions. TRG, Inc. received $29,940 for investigation of applied problems in electromagnetic radiation.

By Commander, HQ AMC, Wright-Patterson AFB: Boeing Airplane Co., was awarded $675,327 for materials equipment to design, pilot produce, test, and evaluate titanium castings suitable for use in aircraft construction. AC Spark Plug Div., General Motors Corp. received $84,634 for bomb-rocket set-gun sighting.

By San Antonio R&D Procurement office, Air Research and Development Command: The Trustees of Tufts College were awarded $25,875 for research on the effects of environmental and nutritional factors on intermediary metabolism.

By Cleveland Ordnance District: Cyril Bath Co., was awarded $49,828 to contract special tooling, frames and rings for guided missiles.

By Philadelphia Ordnance District: Western Electric Company, N.Y. received several contracts totalling $555,281. Western Electric Company (N.C.) received $539,969 for *Nike* spare parts and components. Air Products, Inc. received $584,325 for liquid oxygen semi-trailer. The Research Institute of Temple University received $161,895 for aerodynamic heating tests. The Corporation for Economic & Industrial Research received $66,500 for type 704 digital computer time. Western Electric Co., Inc. received 9 contracts totalling $1,032,612 for *Nike* spare parts and components.

By U.S. Army Ordnance District: Southwest

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. . . Requires no refrigeration . . . Easier to store than liquid oxygen

Performance of Nitrogen Tetroxide as an oxidizer for many fuels is comparable to that of liquid oxygen. In convenience it is far superior to liquid oxygen.

N_2O_4 can be shipped easily and stored indefinitely without refrigeration in ordinary carbon steel containers. It is a dense, mobile liquid that is noncorrosive if kept dry. The quantity of oxygen contained per unit volume of N_2O_4 is 1.01 Kg/liter at 20°C.

N_2O_4 is available in tonnage quantities from Allied's Hopewell, Virginia plant. For experimental purposes, N_2O_4 is available in 125 lb. cylinders and 2000 lb. containers. Write for technical data, and information on prices and delivery.

N_2O_4 Oxidant for liquid rocket propellants

Molecular weight	92.02
Boiling Point	21°C
Freezing Point	−11.3°C
Latent Heat of Vaporization	99 cal/gm @ 21°C
Critical Temp.	158°C
Critical Pressure	99 atm
Specific Heat of Liquid	0.36 cal/gm −10 to 20°C
Density of Liquid	1.45 gm/ml at 20°C
Density of Gas	3.3 gm/liter 21°C, at 1 atm
Vapor Pressure	2 atm at 35°C

Allied Chemical

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Nitrogen Division • Department NT4-40-1 • 40 Rector Street, New York 6, New York

. . . contracts

Research Institute was awarded $182,500 for basic and applied research in fuels and lubricants. R. G. LeTourneau, Inc. received $84,459 for Corporal system repair parts for United Kingdom program. Ralph M. Parsons Co. received $64,831 for instrumentation for hangar. Douglas Aircraft Co. received $70,848 for repair parts for *Nike* system. Firestone Tire & Rubber Co. received $53,000 for guided missile surface-to-surface. North American Aviation, Inc. received 2 contracts totalling $161,000 for rocket engines. Gilfillan Bros., Inc. received three contracts totalling $124,919 for furnishing repair parts for the *Corporal* missile system.

By Los Angeles Ordnance District, U.S. Army: North American Aviation, Inc. received 3 contract awards ($200,000; $50,000; $120,000) for rocket engines. Douglas Aircraft Co., Inc., received $55,861 for repair parts for *Nike* system. Gilfillan Bros. Inc., was awarded $46,080 for replenishment repair parts for the *Corporal* missile. North American Aviation Inc., received $256,703 for digital computer. Firestone Tire & Rubber Co., was awarded $28,603 for guided missile, surface-to-surface. Reynolds Industries, Inc., received $30,949 for technical equipment. Douglas Aircraft Co. Inc., received $294,521 for *Honest John* improvement program. Gilfillan Bros., Inc., received $44,557 for emergency and blue streak requirements of spare parts for *Corporal* missile system. Topp Industries, Inc., received $135,739 for angle of attack transducers. Lear Inc. received $146,136 for gyroscope. Reynolds Industries, Inc., received $30,949 for technical equipment. Douglas Aircraft Co. Inc., received $294,521 for Honest John improvement program.

Gilfillan Bros. Inc., received $44,557 for emergency and blue streak requirements of spare parts for *Corporal* missile system. Topp Industries, Inc., received $135,739 for angle of attack transducers. Lear, Inc. received $146,136 for gyroscope. Gilfillan Bros. Inc. received 5 contracts totalling $380,576 for furnishing and delivering of replenishment repair parts for Corporal missile system. Firestone Tire & Rubber Co., received $86,931 for replenishment repair parts for guided missile, Artillery M2, and related ground handling equipment. Aerophysics Development Corp., received $494,000 for reports for drop test of *Jupiter* nose cone, individual and final. G. M. Giannini & Co. Inc., received $60,780 for pressure transmitters.

By New York Ordnance District: Western Electric Co. Inc., received $85,932 for *Nike* spare parts and components. Linde Co. Div. of Union Carbide Corp. received $367,583 for nitrogen converter. Tenney Engineering, Inc. received $47,377 for environmental test installation.

By Army, Chicago Ordnance District: American Machine & Foundry Co., has been awarded $59,910 for thruster supply contract. A. O. Smith Corp. received $80,850 for nitrogen receivers supply contract. Flexonics Corp. received $26,000 for supply contract expansion joints and hose assembly for missile. D. W. Onan & Sons, Inc. received $31,605 for repair parts for launcher rocket.

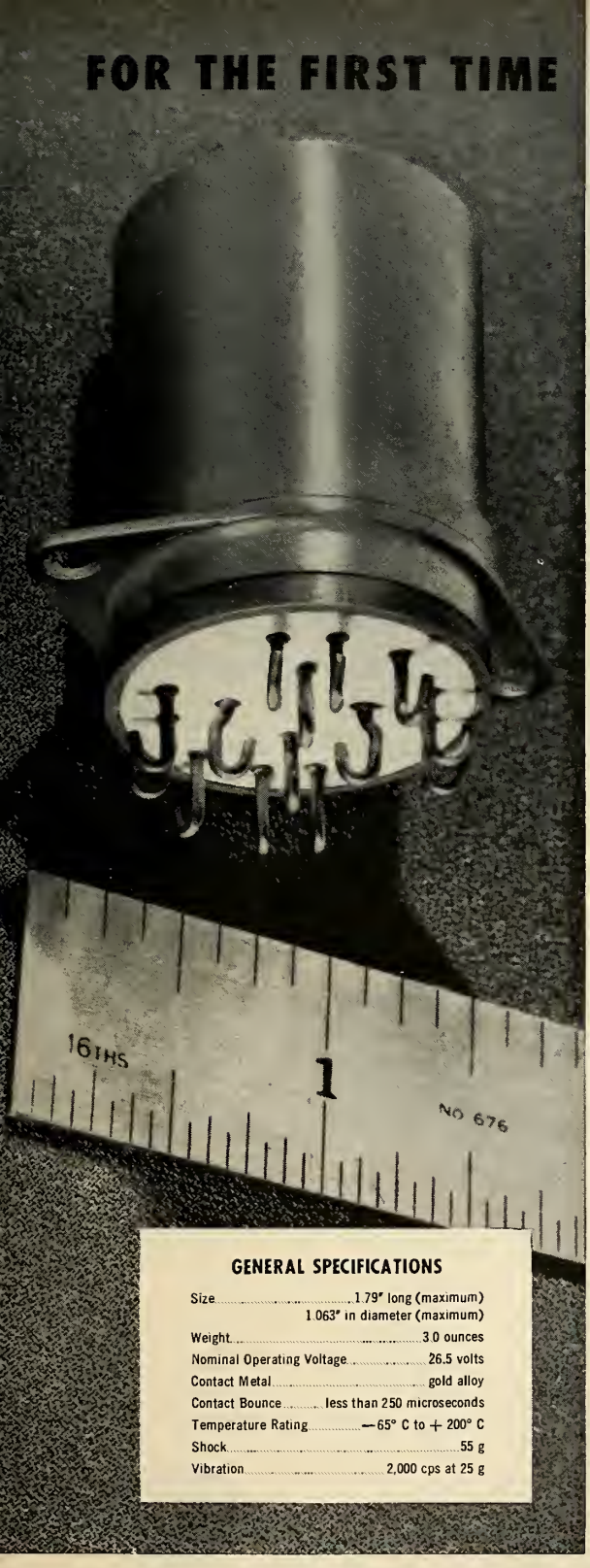
By Army: The Martin Co., Orlando Fla. received $16 million for production of La-Crosse guided missiles and related equipment. Burroughs Corp. of Detroit received $3,891,027 for production of electronic communications equipment.

The Martin Company announced that Hallamore Electronics Co., a division of the Siegler Corporation of Anaheim, Calif., has received a $3 million addition to its contract for instrumentation and field test equipment work on the USAF *Titan* Intercontinental Ballistic Missile.

By Purchasing and Contracting Division: The Perkin-Elmer Corp., received $61,960 for infrared rapid scan spectrometer.

By Secondary Items Section, Industrial Division, Redstone Arsenal: The Waco Aircraft Co. received $51,464 for skin assembly.

By Redstone Arsenal, U.S. Army: Linde Co. Div. of Union Carbide Corp., was awarded $117,300 for liquid nitrogen and liquid oxygen. Thiokol Chemical Corp. was awarded $29,025 for development and delivery of XM9E1 Jatos; $35,000 for facilities for development, manufacture & delivery of TX62 rocket engines; $152,407 for design and development of solid propellant vernier engine.



a new 4PDT relay to meet all requirements of MIL-R-25018!

Don't compromise with the Class C, Type II, Grade 3 requirements of MS 24114-9, MIL-R-25018. You don't have to any more. Now Union Switch & Signal has a 4PDT, rotary-armature relay designed to meet these specifications *completely*. It is the first of its type to do so. In fact, it *exceeds* some of the rugged requirements.

Here is the kind of performance you can expect from this new relay:

High operating temperature. Even at an ambient temperature of 200° C, this relay gives optimum performance. The use of ceramic material provides consistently high insulation resistance. As a result, you can install this relay closer to engines. You often can use it *without* temperature controlled boxes. Always, you will find it supremely rugged and reliable.

High in shock resistance. This new UNION Relay withstands shock *greater* than 55 g for 11 milliseconds—and continues to operate. In vibration tests, it shows no contact chatter up to 2,000 cycles at an acceleration of 25 g.

New high in contact reliability. Contact reliability of this relay is *six times* that of comparable devices because of its new 2-button, bifurcated contacts. Bifurcation also increases current carrying capacity (each button easily handles a full 2-ampere load) . . . and makes gold alloy contacts practical for both low- and high-level loads.

Contact reliability is enhanced, too, by the ceramic insulation which contains no volatile material to contaminate contacts and by separate hermetic sealing of the magnet coil.

New torsion-type rotary-armature suspension improves resistance to thermal shock . . . increases reliability over the entire temperature range . . . and greatly extends the operating life of this new 4PDT relay. Call or send the coupon for complete information about this and other miniature relays manufactured by Union Switch & Signal.

GENERAL SPECIFICATIONS

Size	1.79" long (maximum) 1.063" in diameter (maximum)
Weight	3.0 ounces
Nominal Operating Voltage	26.5 volts
Contact Metal	gold alloy
Contact Bounce	less than 250 microseconds
Temperature Rating	—65° C to + 200° C
Shock	55 g
Vibration	2,000 cps at 25 g

COMPLETE FACTS

Union Switch & Signal,
Division of Westinghouse Air Brake Co.
Pittsburgh 18, Pennsylvania

Please send the following:

☐ Complete description of your new 4PDT relay which meets every requirement of MIL-R-25018. ☐ Catalog of other miniature dc and ac relays which you manufacture to MIL-R-25018, MIL-R-6106C, and MIL-R-5757C requirements. ☐ Description of your Digital and Alpha-Numerical Indicators for data display.

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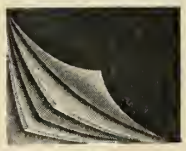

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HITCORE Honeycomb
In Stainless Steel and a variety of other materials. Various thicknesses, core sizes and foil gages can be combined to meet your special requirements.

. . . contracts

Rohm and Haas Company received $214,800 for research & development of solid propellant rocketry. Consultants and Designers, Inc. received $370,000 for 6100 additional man-hours of engineering services.

By U.S. Army Signal Supply Agency: Armour Research Foundation of Illinois Inst. of Technology was awarded $84,357 for research work pertaining to radar generated interference. RCA Service Co. Inc. received $31,916 for installation and operation of radio equipment for propagation studies. Cook Electric Co., received $82,447 for research for *Nike I* electronic parts. Belock Instrument Corp., received $28,654 for investigation Army Signal System interference. New York University, College of Engineering, received $209,988 for research to supply technical and secretarial personned for the Advisory Group on Electron Tubes. Kaysam Corp. of America received $45,352 for research for investigation of the physical characteristics of balloons and balloon materials. Dewey and Almy Chemical Co., Div. W. R. Grace & Co., received $38,710 for balloon high altitude. Emerson Research Labs. Div., Emerson Radio & Phono. Corp., received $123,067 for millimeter communication equipment. Hewlet-Packard Co., was awarded $115,105 for high frequency oscilloscope. Dynac, Inc. received $79,302 for generators. Philco Corp. received $25,600 for retma transister. The James Knights Co., received $41,693 for frequency standard, high stability. Sylvania Electric Products, Inc. received $90,000 for magnetron, QK-362A, wigh SM connectors. The Machine & Tool Designing Co., received $53,248 for studies of piezolelectric crystals. Arcs Research & Development Corp., received $68,798 for transformers. Airborne Instruments Laboratory, Inc., received $33,680 for hydrogen line receiver. The State Board of Higher Education of Oregon State College received $30,926 for research for investigation on Army Weather Observation. Bendix Aviation Corp. received $863,668 for wind measuring set. Armonr Research Foundation of Iil., Institute of Technology, received $87,656 for research and development of miniature RA cables and connectors.

By U.S. Army Engineer Division: James Farina Corp., received $200,685 for Construction of field unit integration facilities at twelve *Nike* sites. Anderson-Nichols Co., was awarded $80,040 for SAC missile facility, Ethan Allen AFB. The Bridge Construction Corp. received $166,720 for alterations and additions for *Nike* for Loring AFB defense area.

By Army Map Service, Corps of Engineers, U.S. Army: Hal Peterson, DBA International Aerial Mapping Co., was awarded $182,020 for Western U.S.S.R. topographic map compilation.

By District Engineer, U.S. Army Engineer District: J. W. Bateson Co. Inc. received $676,531 for Hawk engineering and contractor facilities. V & N Construction Co. received $153,981 for storage, base and rocket assembly; Walker Air Force Base.

By U.S. Army Engineer District, New York, Corps of Enginers: Middlesex Concrete Products & Excavating Co. received $143,018 for improvement program special AAA facilities. Nassau Construction Co. Inc., received $60,200 for improvement program special AAA facilities. Grant Park Construction Co. received $145,353 for improvement program special AAA facilities. Heroes Excavating and Contracting Corp. received $195,814 for special AAA facilities, conversion of *Nike Ajax* to *Hercules*.

By U.S. Army Engineer District, Philadelphia: Keane Construction Co. Inc., was awarded $276,468 for construction of conversion to *Nike-Hercules* in the Philadelphia Defense Area. Peterson, Garbi & Joseph, Inc. received $147,000 for construction of high altitude training building, Little Rock AFB. Hardee Construction Co. Inc. received $119,-655 for high altitude training building, Carswell AFB.

By U.S. Army Corps of Engineers, Office of the District Engineer: Toltz, King, Duvall, Anderson and Associated, Inc., was awarded $80,800 for contract plans for four *Nike* installations. Consolidated Diesel Electric Corp. received $5 million for ground support electrical generators.

By U.S. Army Engineer District, Mobile, Corps of Engineers: Blount Bros. Construc-

op′ por·tu′ ni·ty

KEY OPENINGS IN 4 ADVANCED ENGINEERING AREAS AT VOUGHT

ADVANCED WEAPONS

This Vought division is planning, analyzing and proposing new concepts in missile and fighter weapon systems. Here, tactical requirements are established for new weapons, feasibility studies conducted, and proposals prepared.

Select openings exist in both the Advanced Missile Technical Group and the Advanced Aircraft Technical Group. These are responsible positions for engineering specialists and for design engineers up through lead level. Following are requirements for 5 openings which are typical of others in these groups:

Electro-mechanical Systems Analyst. A.E., E.E., or M.E. (advanced degree preferred) with 8 to 10 years experience in analytical design of guidance controls, flight mechanics, dynamics, or comparative applications of applied math. To study advanced weapon systems for guidance, controls, autopilots.

Radar System Engineer or Specialist. A.E., or E.E. (M.S. preferred) with at least 7 years experience in systems and/or design for radar and fire control. To make high-level studies of advanced guidance and control systems.

Advanced Weapons Staff Engineer. Ph. D. preferred, with at least 10 years background in guidance or navigation and control systems. To develop completely new concepts in guidance, navigation, or control systems.

Electro-mechanical Systems Engineer or Specialist. A.E., E.E., or M.E. (advanced degree preferred) with at least 7 years experience in autopilot, flight control, stability systems and inertial guidance systems and design work. To make high-level technical studies of various control and stabilization systems for advanced weapons.

Advanced Weapons Engineer. A.E., E.E., or M.E. (M.S. desirable) able to develop methods for dynamic stability and stabilization studies. To join in, or direct, studies in stabilization, dynamic stability, missile and airframe configurations, and to make flight path and trajectory analyses. All in supersonic and hypersonic range.

AERODYNAMICS

Some of Vought's most vital and interesting problems are in general aerodynamics and automatic flight controls for supersonic and hypersonic weapons. This work involves trajectory and configuration analyses, autopilot studies, control system synthesis and other responsible investigations. Helpful in a number of areas are Vought's low- and high-speed wind tunnels with a speed range from Mach .05 to 5.0.

A limited number of additional specialists may find assignments to match their skills in Vought's aerodynamics activities. These men may have general aerodynamics experience, or a good background in automatic flight control systems. Illustrative of openings available are these 2 posts:

Autopilot Engineer. A.E., E.E., or M.E. (M.S. desirable) plus at least 3 years experience in stabilization, or autopilot and servomechanism analysis and design. To assist in, or direct, autopilot studies and designs for supersonic airplanes and missiles.

Aerodynamics Engineer. Aerodynamics Engineer with A.E., or equivalent, and at least 3 years experience. To work on supersonic aircraft and missiles in aerodynamic analyses of performance, air loads, stability and control, or fluid mechanics.

STRUCTURES

Structures work at Vought is an interesting combination of research, analysis, design and test—a mixture of practical and theoretical problems. Model tests in wind tunnel and on rocket sleds, together with high-speed digital computation, are used extensively for stress, flutter analysis, and dynamic response calculations.

At lead and staff levels in this activity, a few positions of responsibility are open. Especially attractive to men with solid backgrounds in applied mechanics or mathematics, or to men with wide knowledge of structural aircraft elements, are these 3 immediate openings:

Engineering Specialist. Requires Ph. D. To conduct R & D in structural and dynamic loads determinations, or to apply advanced mechanics theories to the solution of structural design problems where high temperatures are a prime factor.

Solid State Physicist. Ph. D. preferred, with at least 5 years experience. To assist in studies of: corrosion control; nuclear radiation damage; parts or systems failures for which no causes are apparent; basic phenomena of solids leading to new concepts.

Lead Structures Test Engineer. Engineer (M.S. preferred) with 5 years experience in structures or related field covering power controls, hydraulics or hydraulic systems, and control systems. To direct groups of engineers in work on structural aircraft elements, components and complete aircraft, including test work and report writing.

ELECTRONICS

Electronics activities are broad and fast-growing at Chance Vought. Projects involve advanced guidance and control and fire control systems for missiles and high-performance manned aircraft. They begin with investigations and theory and progress through systemization and packaging to detailed hardware design. Key responsibilities await additional men who are qualified in these areas. Advanced degrees are preferred. Following are 4 openings in this area:

Stability and Control Engineer. E.E., M.E., or A.E. with emphasis on flight stability and control problems or dynamics. (Special consideration given graduate study or extensive experience in transients or closed loop stability analysis.) To assist in design of autopilot and control systems for high-performance missiles and aircraft.

Antenna Design Engineer. E.E., or Physics Degree with demonstrated aptitude for antenna design. To join active projects involving design of flush-mounted, recessed and external antennas at all frequencies for very high-performance aircraft and missiles.

Fire Control and Microwave Systems Engineer. Requires E.E., or Physics Degree; at least 2 years experience in radar, data link, or fire control systems; and strong ability in this work.

Test Equipment Engineer. Requires E.E., or Physics Degree and at least 2 years experience in this or related field. (Desirable: broad background in electronics design with emphasis on digital computers or microwave systems.) To join in the design of complete checkout systems for missiles and associated subsystems.

To arrange for a personal interview, or for a prompt report on these or other current openings, return coupon to:

C. A. Besio
Supervisor, Engineering Personnel
CHANCE VOUGHT AIRCRAFT,
Dept. P-4
Dallas, Texas

I am a _____ Engineer,

interested in the opening for _____.

Name _____

Address _____

City _____ State _____

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

re·lent′less: *a missile that pierces hostile sky to pinpoint its nuclear strike*

When a target's latitude and longitude are marked on this missile's brain, an appointment has been made.

To keep its rendezvous, the Chance Vought *Regulus II* performs miracles of navigation: it will launch stealthily from submarines — nuclear and conventional — from surface craft and mobile shore launchers. It will compensate automatically for wind and weather and for the earth's rotation. It will detour enemy strongpoints, outfox known counterweapons. Closing in on its quarry, it can plummet from over 60,000 feet to smokestack height to escape radar detection.

In minutes, *Regulus II* can pierce over 1,000 miles of hostile sky to score a nuclear bull's-eye.

The first of the Navy's nuclear-driven subs, designed to roam the seas as unseen *Regulus II* bases, is now in construction. The missile itself has made over 25 successful flights. Under Navy leash in key locations, it will be a relentless watchdog for peace.

Scientists and engineers: pioneer with Vought in new missile, manned aircraft, and electronics programs. For details on select openings write to: C. A. Besio, Supervisor, Engineering Personnel, Dept. P-3.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

. . . contracts

tion Co. received $1,506,154 for construction of interim troop housing at Redstone Arsenal. E. F. Gunn Construction Co. received $129,982 for construction of rocket storage. Westinghouse Electric Corp. received $151,265 for oil circuit breakers and transformers, Eglin AFB. Moloney Electric Co., received $43,971 for voltage regulators for Eglin AFB.

Lacrosse: The Army has let another research and development contract in connection with the 20-mile-range *Lacrosse*. The contract, amounting to $1,746,930, was awarded to Cornell Aeronautical Laboratory, Buffalo, N.Y. Contracts have also reportedly been awarded by the Air Force to Food Machinery and Chemical Corp. for launchers for the latest version of *Bomarc*. Developmental launchers were built by American Machine & Foundry Corp. It is also understood that Goodyear Aircraft at Phoenix, Arizona, has been awarded a contract to make the ground handling equipment for *Atlas*.

Electronic equipment and maintenance spare parts kits: $10,831,030 by Army to Burroughs Corp.

Plato: $4.5 million for research and development to Sylvania Electric Products, Inc., by Army.

Solid rocket development: $1.5 million to Aerojet-General Corp., by Air Force.

Snark Launchers: $1 million to Nuclear Products—Erco div., ACF Industries, Inc., by Northrop.

By U.S. Army Signal Supply Agency: National Co., Inc. received $42,500 for frequency standard atomic atomichron. Board of Regents of University and State Colleges of Arizona, received $30,923 for combined study and investigation of an experimental transistorized distributed amplifier. Arthur D. Little, Inc. received $25,924 for standard "Arthur D. Little" collins helium cryostat. Syracuse University Research Corp. received $48,548 for research on radar sensors. Admiral Corp. received $70,870 for antenna models.

U.S. Army Engineer District, Pittsburgh, Corps of Engineers, received $204,781 for construction of F.U.I.F. room addition and generator building modifications at control area of *Nike* sites.

By U.S. Army Engineer District, Jacksonville, Corps of Engineers: Anchor Post Products, Inc. of Florida received $45,769 for construction of security fence for complexes 11, 12, 13 and 14, AFMTC, Patrick AFB. Paul Smith Construction Co. received $1,364,349 for construction of G/M lab engineering, SM-62 and base communications buildings. Maurice H. Connell and Associates, Inc. received $60,000 for design of complex 29 facilities and facilities in missile assembly building.

By Boston Ordnance District, Army Base, Boston, Mass.: Anderson-Nichols and Co. received $42,605 for design & development of data-recorder instrument.

By Rome Air Force Depot, U.S. Air Force, Griffiss Air Force Base: Collins Radio Co., was awarded $59,430 for single sideband equipment for SM-75.

By Dept. of the Navy, Office of Naval Research: Brown University received $25,428 for study of the three-dimensional state of stress in elastic plates. Hughes Aircraft Co. received $45,000 for development of a gridded controlled electron gun. Yale University received $47,199 for research on the effects of environment on the failure of metals; $30,000 for laboratory and theoretical studies of the fluctuation of acoustic waves in water.

By Air Force Cambridge Research Center, Air Research and Development Command: The University of Chicago received $30,000 for research relating to molecular structure-high resolution spectroscopy of atmospheric gases. Allied Research Associates, Inc. received $64,946 for research directed toward contrail elimination. The Johns Hopkins University received $30,000 for research concerning extreme ultraviolet gratting. Northeastern University received $40,000 to develop, modify, fabricate and test upper air vehicle components.

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missile business

by Seabrook Hull

One thing about the missile business—It takes some traveling. Anyhow, it does if you're going to make a go of it. The most obvious reason for travel is sales. But there are other reasons, just as important. For example, considering Pentagon classification, censorship, and need to know; compounded with the natural inclination of most companies to keep as much of the prime contract in the shop as possible; traveling is often the only way to learn about new business in time to get it. Also, to be a success in the missile business, you've got to sound like an expert. To sound like an expert, you must have a pretty good idea of what's going on. The only way this is done is by hitting the trail, talking to people, listening, pumping.

When traveling, you can also manage to keep up-to-date of who your competition is; what new processes have been developed; who's goofed; and where the next big contract is going to be placed. In a word, one important phase of selling missiles requires a continuing running market survey and analysis. You can't do this with your feet propped on your desk. Hit the road!

The missile, rocket and space flight business is twice as big as you think it is. Take a look at the expenditures. Missile procurement is pegged at $2.9 billion for the current fiscal year, and at $3.3 billion in 1959—not counting the supplemental appropriations. But this is only section "B" of the major budget item, Category III—Major Procurement and Production. This refers to the missile itself and its immediate support equipment. It doesn't include other support vehicles such as road missile transporters, fixed base liquid oxygen generators, storage tanks, and others. It doesn't refer to based electronics such as acquisition radar, site-to-site communications, and the like. Another major item not included in "Category III, B" is site construction—concrete, black top, barracks, bunkers, sewers, waterworks, telephone exchanges.

And perhaps most important of all, this category doesn't include research and development. This last item—major Category VI—will hit $1.8 billion plus this year and will top $2.1 billion in 1959. A large hunk of both figures is for missiles, rockets and space flight.

All these extras added together will probably raise the total missile market to twice the normally stated size. And, if you want to add to such items as Polaris-launching submarines, missile cruisers, Government financing of new production facilities—the market turns out to be even bigger.

Since the Pentagon is still at a loss on the matter, we did some looking ahead ourselves the other day at how the Federal Missile budget will look after fiscal 1959. Again, we're only talking about "Category III, B"—Missile Procurement and Production. We figure the missile, rocket and space flight market will develop something like this: 1960, $4.5 billion; 1961, $5.5-to-$6 billion; 1965, over $10 billion; 1970-75, over $15 billion. All figures are in terms of 1958 dollars and do not include inflationary rises.

NORTHROP AIRCRAFT, INC., ANNOUNCES

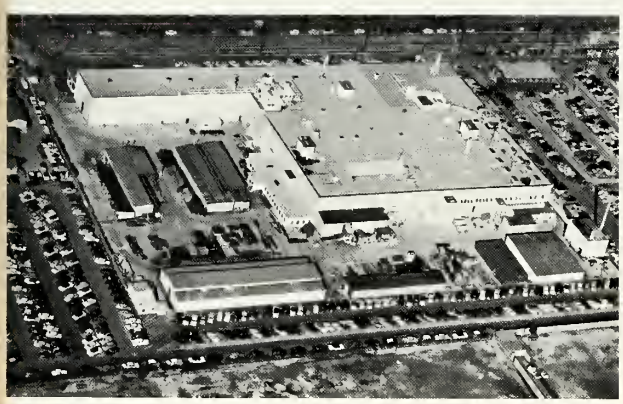
THE FORMATION OF NORTRONICS

A DIVISION OF NORTHROP AIRCRAFT, INC.

NORTRONICS

...GEARED TO THE SPACE AGE

Today, in the complex field of applied electronics, a new name, NORTRONICS, represents the combined talents of leading scientists, engineers, and technicians with production experience and capabilities. NORTRONICS, *new in name only,* is a combination of several Northrop facilities which had separately provided technical design, development, and production of electronic systems and systems support equipment. NORTRONICS provides a complete organization with the scientific knowledge, development techniques and production capabilities specifically required for the space age.

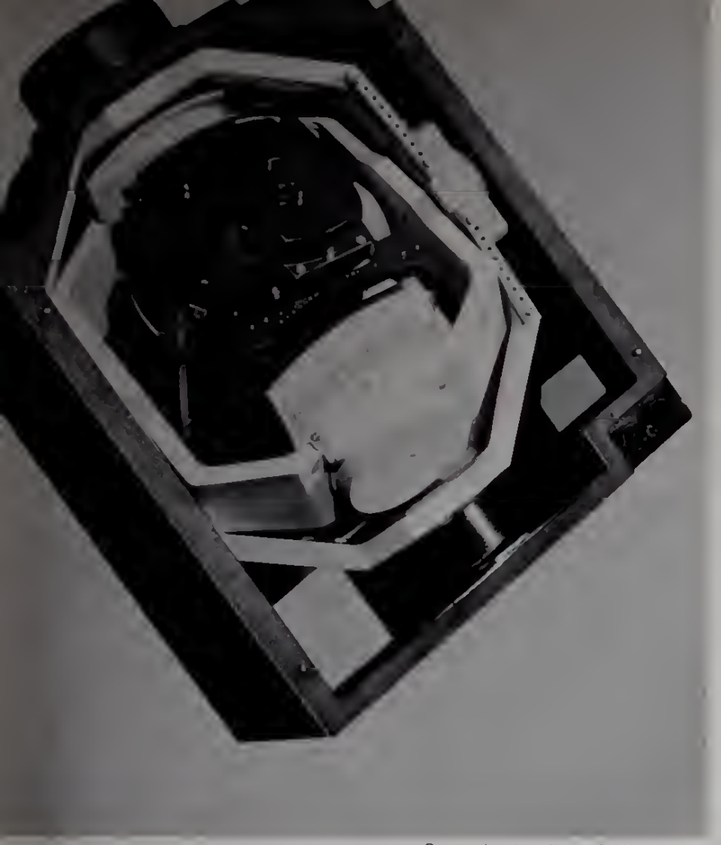


Nortronics' Electronic Systems and Equipment element, 222 North Prairie Avenue, Hawthorne, California.

In this NORTRONICS facility, comprising 300,000 square feet of plant area, Northrop established the nation's first unmanned weapon systems project. This program developed and produced the first successful systems for intercontinental inertial guidance. Today, airborne and ground based digital computers, automatic flight control systems, advanced infrared applications, and electronic and precision optical equipment are being developed and produced.

Nortronics' Systems Support element, 500 East Orangethorpe Avenue, Anaheim, California.

Here NORTRONICS is engaged in weapon systems support, including electronic test equipment; launching, loading and handling equipment; opto-mechanical fire control and sighting devices; and the most advanced techniques in physical countermeasures. The technology and facilities required to support such projects are housed in a 350,000 square foot plant area.



Compact automatic navigation system

AUTOMATIC FLIGHT CONTROL

A special research and development program of electronic miniaturization for advanced flight control application is now in progress at NORTRONICS. This is an outgrowth of nearly twenty years' experience in flight control systems for manned and pilotless aircraft. The fully powered systems on the Northrop P-61 Black Widow, the F-89 Scorpion series, and the SM-62 Snark missile were products of what is now NORTRONICS. These capabilities and production facilities are adaptable for the development of various types of flight control systems.

INFRARED INTELLIGENCE SYSTEMS

Homing systems for air-to-air missiles and infrared reconnaissance systems are natural outgrowths of development at NORTRONICS, following years of creative study. Considerable engineering development has resulted in experience in the fields of critical infrared systems and components, interference filters, reflecting optics, and sensor refrigeration.

DIGITAL COMPUTERS

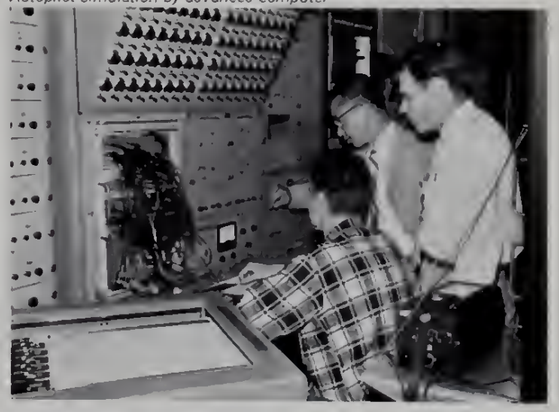
The engineering team that is now part of NORTRONICS developed advanced digital computing techniques employing a magnetic drum storage principle. The quadratic arc computer, identified as QUAC, followed and is now in production for the U.S.A.F. Later NORTRONICS engineers developed the first successful computer design employing the moving pick-off head principle. This computer series, known as GFC, is also in production. The requirement for lightweight, accurate airborne parabolic arc computer systems was met with APAC, a fully transistorized missile computer.

AUTOMATIC NAVIGATION

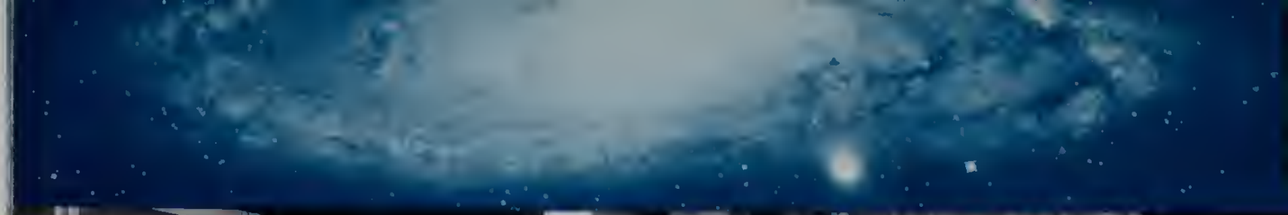
NORTRONICS scientists and technicians developed and produced the world's first successful intercontinental inertial guidance system. Aircraft and missile guidance systems of extreme accuracy and reliability, utilizing automatic star-tracking, are now in production. This vast experience has led to unique capabilities for the development of interplanetary navigation systems. NORTRONICS operates complete testing and manufacturing facilities for numerous types of automatic navigation systems.

Inertial guidance manometer accelerometer

Autopilot simulation by advanced computer



Rapid digital computer memory drum



Electronic support test equipment

ELECTRONIC TEST EQUIPMENT

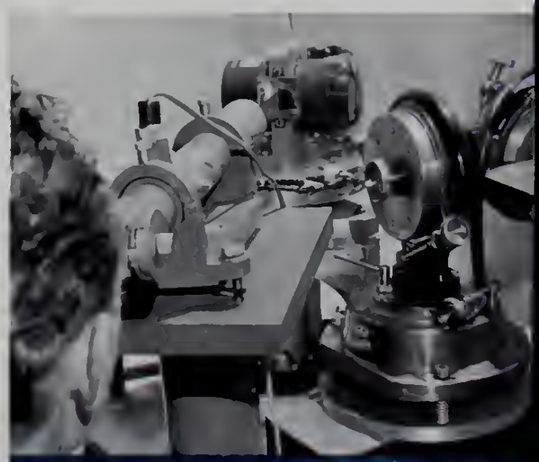
Experience in the field of automatic test systems for complex weapons includes the design, development, and production of a complete line of operational support equipment for the SM-62 Snark missile guidance system. Latest in a series of successful test equipment is DATICO, a digital automatic tape intelligence checkout system. DATICO provides a major reduction in the time and costs involved for the testing of all types of weapons. The versatility of this equipment is demonstrated by its current application to five weapon systems.

Precision electro-optical development

ELECTRO-OPTICS

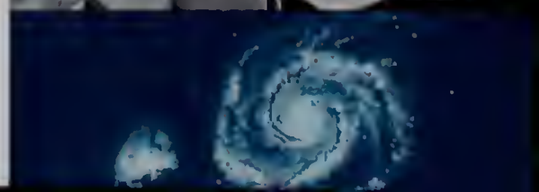
In one of the nation's most complete optical laboratories, NORTRONICS combines advanced navigation systems with new developments in optical science. NORTRONICS' modern optical laboratory is staffed with specialists of outstanding and unique skill and experience. Here a wide range of precision optical elements is produced, ranging from simple prisms to specially designed test equipment and precision lenses. At present, these NORTRONICS scientists and technicians are specifically qualified to conduct advanced research for interplanetary navigation.

High precision optical test equipment



ENVIRONMENTAL TEST FACILITIES

The wide range of environmental conditions encountered by all types of electronic systems can be duplicated by NORTRONICS' extensive test facilities. Extremes of temperature, altitude, humidity, pressure, and sound frequency are simulated, as well as combinations of random and sinusoidal vibrations that occur during flight. Additional NORTRONICS testing equipment is constantly being designed and developed to meet changing requirements.



A DIVISION OF NORTHROP AIRCRAFT, INC.

FIRE CONTROL AND SIGHTING DEVICES

Experience in fire control devices and sighting sub-systems at NORTRONICS covers a wide range of production items. NORTRONICS has engineered, designed, tooled, and volume produced telescopes, periscopes, range finders, plotting devices, and calibration and alignment fixtures for military and industrial applications.

LAUNCHING, LOADING AND HANDLING EQUIPMENT

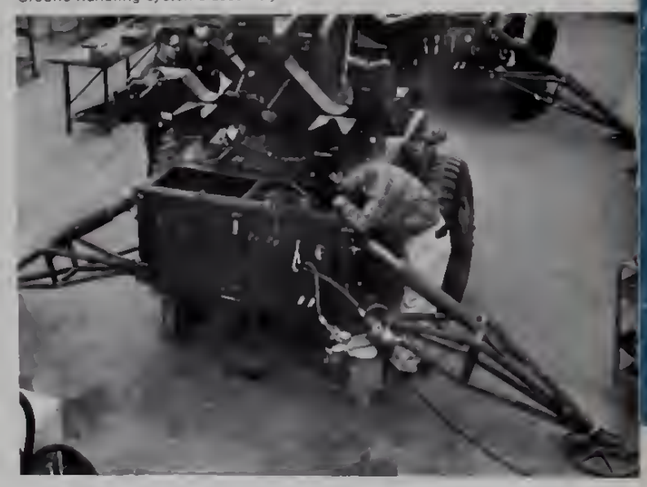
The capabilities of NORTRONICS cover the complete range of research, design, development, production and service of universal handling equipment for major weapon components. NORTRONICS is currently supplying Raytheon Manufacturing Company with pallets, loaders, launchers, and tactical containers for the Hawk missile, and has participated in other similar programs.

SUPPORT SYSTEMS DEVELOPMENT

The design of support equipment must reflect understanding of the weapon, its operational and maintenance concepts, and the facilities and skills of its field operators. NORTRONICS' experience with military specifications, contracts and documentation, operational concepts, and the design and production of weapon systems support equipment provides maintainable precision support equipment having high reliability.

Military fire-control equipment

Ground handling systems assembly



Weapon systems support equipment

NORTRONICS

...GEARED TO THE SPACE AGE

Scientific knowledge of the highest degree, proven development techniques, and precision production abilities are demanded in today's space age. NORTRONICS, the new Division of Northrop Aircraft, Inc., is a unique combination of these required capabilities. Here are the scientists and engineers who have created such outstanding achievements as the world's first successful automatic intercontinental missile guidance system, now being produced by NORTRONICS' skilled technicians. Exploration and discovery in every field of aerial science and weapon systems is represented in the combined experience of NORTRONICS.

1—NORTRONICS is a *complete* organization. It offers systems analyses, applied research, design, development, engineering, laboratory and flight testing. It offers special environmental test facilities, assembly line manufacturing, production of training aids and technical publications, and field services.

2—The Engineering and Research staff of NORTRONICS includes over 450 scientists and professional engineers. More than 4,500 experienced people work in 650,000 square feet of plant area.

3—NORTRONICS designs, develops, and manufactures electronic, electro-mechanical and opto-mechanical systems, components and ground support equipment. In 1957, sales amounted to $60,000,000.

4—Advanced engineering research at NORTRONICS has resulted in the development and production of several types of highly refined analog and digital computers for both airborne and ground based applications.

5—Extensive experience makes NORTRONICS an important source of weapon systems support equipment. Now in production, for example, is electronic and mechanical ground support equipment for leading United States missiles.

6—NORTRONICS' completely equipped optical laboratory is manned by technicians with unique skills and experience in developing high precision optical elements and systems.

7—NORTRONICS' scientists and engineers pioneered in celestial and inertial guidance and navigation systems. This experience is particularly applicable to the development of infrared guidance and interplanetary navigation systems.

The research facilities as well as the development and manufacturing capabilities of NORTRONICS are now supporting U.S. science, industry and military services. For further information write to: NORTRONICS, A Division of Northrop Aircraft, Inc., 222 North Prairie Avenue, Hawthorne, California.

west coast industry

by Fred S. Hunter

Half-ton U.S. Satellite?—There have been reports in Pasadena, where Caltech's Jet Propulsion Laboratory is located, that the Army is undertaking a full-scale satellite program aimed at orbiting a half-ton satellite before the International Geophysical Year ends. And Marvin Miles, the Los Angeles Times aviation editor, has been trying to find out if JPL is engaged in a study for a solid propellent ICBM for the Army. But he got no clues from Dr. William Pickering. In answer to Miles' question, the JPL director merely pointed out that the facility does not engage in projects as such, but rather performs the research paving the way for desired achievements. Miles' guess is that JPL actually is researching the possibilities of a solid ICBM for the Army.

More to come—J. L. Atwood, North American Aviation president, made an interesting observation at the annual stockholders' meeting. NAA's Rocketdyne division, he said, "has only begun to scratch the surface." It is going on to larger and more efficient engines. Another point: "There is a distinct and discreet division between liquid and solid propellant engines." Liquids are better for large engines; solids are advantageous for smaller engines, he explained.

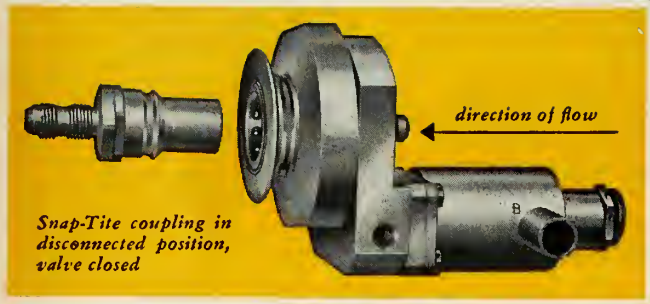
What's in a name?—Marquardt Aircraft Co. calls its new research division ASTRO, which, of course, is a combining form from the Greek "astron" for star, but at Marquardt it means Air-Space Travel Research Organization. Roy Marquardt, incidentally, believes air-breathing engines accelerating to satellite velocities within the atmosphere will supply a very efficient way of setting up and servicing a manned space platform, which, he adds, will almost certainly be established within the next 10 years, "leading to colonization of our planets within our lifetime."

But if you think it would be romantic to go to the moon, listen to this observation from H. Guyford Stever, chairman of the Scientific Advisory Board committee on space technology: "Personnel assigned to scientific observations from moon stations will find it about as interesting as Thule Air Force Base."

Ramo-Wooldridge is sounding a new note in its personnel procurement advertising. Its help-wanted ads announce that its reconnaissance-data processing programs have created openings for engineers experienced in photogrammetry and in photo interpretation.

High cost of gyros—William R. Whittaker, president of Telecomputing Corp., told stockholders at the annual meeting that 10% of a *Nike's* cost is in its gyros. All of the *Nike's* gyros are produced by Telecomputing. "You can see what a nice business this is," he said. Telecomputing is now getting into production on gyros for the upgraded *Hercules.*

SNAP-TITE REMOTE CONTROL COUPLINGS FOR GUIDED MISSILES



Snap-Tite coupling in disconnected position, valve closed

Here is a specially designed Snap-Tite quick-connect, quick-disconnect coupling, ideal for use in missile-fueling systems. This unit is specifically designed to be manual-connected . . . can also be disconnected manually, or by use of an air-actuated remote control.

NOT A DROP SPILLED!

When the coupling is disconnected, it spills only that small amount of fluid which clings to the metal. The valves in both the coupler and nipple automatically shut off when disconnected, *with no leakage.*

NO AIR INCLUSION!

Coupling operation encloses only a minute amount of air.

MINIMUM PRESSURE DROP!

Smooth, streamlined passages assure maximum flow.

Variations of this coupling, to meet your required specifications, can be furnished with the appropriate seals to handle liquified gasses, exotic fuels, and a large variety of fluids with working pressures up to 3,000 PSI and temperatures from −300°F to +400°F. Units have been designed up to and including 5″ size.

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Your coupling needs might not be as critical as the coupling shown here, but you can be sure, when buying standard Snap-Tite couplings, that the same outstanding engineering and manufacturing skills are basic throughout the Snap-Tite line. Write for complete catalog . . . or describe your specific coupling problems. Snap-Tite, Inc., Union City 12, Pa.

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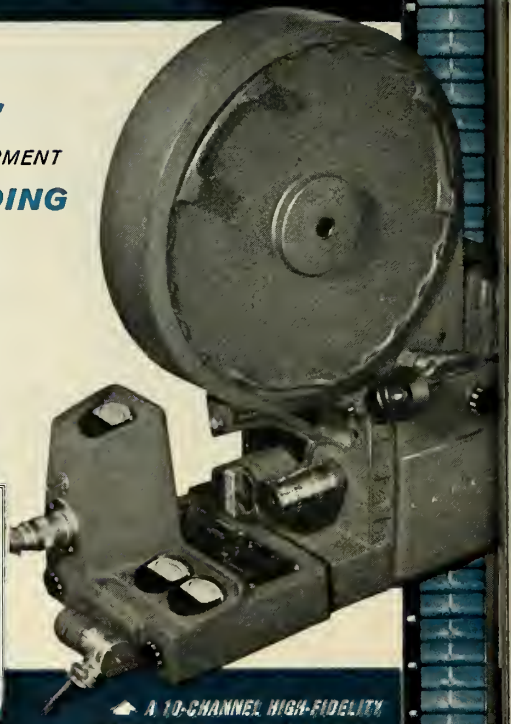

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washington trends

by William O. Miller

Reluctant brides might be one way of describing the three services, in regard to the President's reorganization proposals. Just how unpleasant the word "reorganization" sounds depends on whose shop you're in—with the Navy the most reluctant and the Army in the middle. Since the President pointed his finger at them, the information offices are watching and waiting. As far as can be determined, none of the information chiefs have been consulted. One thing seems sure—if the information merger goes through, security review activities will be greatly increased. Increased security or censorship will result, depending on how you look at it. The general feeling in all services is that turmoil will come just as the stormy common law marriage of the Services and DOD was beginning to work.

The second most important word—after reorganization—in Washington is "space," but there seems to be some difficulty in defining it. Every witness called before the new House Committee on Astronautics and Space Exploration were asked the same questions: "Where does space begin?" "How far should the Committee's jurisdiction extend?" Answers varied from witnesses Wernher Von Braun and Dr. Hagen. Von Braun suggested the Committee should stick to the solar system.

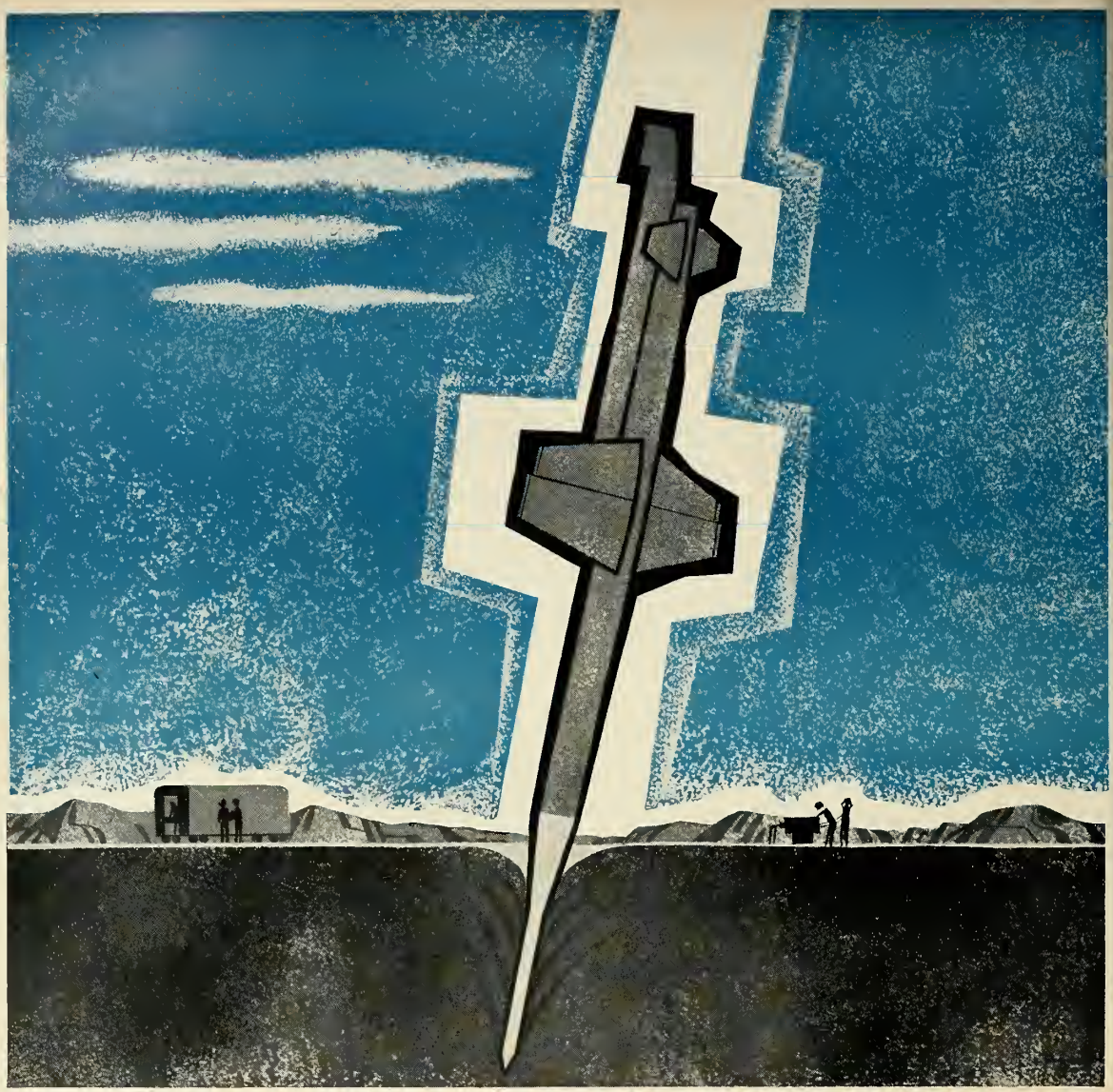
A new air-to-air missile system is being sought by the Navy as the answer to rising costs of high-speed aircraft. BuAer spokesmen say competition has been launched in an effort to enable missiles to carry out a larger part of interceptor duty. Fighters now being considered by the Navy carried small-lot price tags ranging up to almost $10-million each.

Liquid rocket auxiliaries for fighters and attack aircraft are becoming more important. The Navy still has not announced the winner of competition for a successor to the AR-1, but indications are that one of the first planes to use the new booster will be North American's A3J. Use of liquid rocket auxiliaries is slated for several other types.

A single specification for procurement of engineering drawings, to become effective within a year, is the latest goal of the Defense Department. At present, engineering drawings are prepared in accordance with about 28 different specifications. Two questions are being asked: "Who's going to pay for the standardization, and what is going to happen to the old drawings?" It takes about 30,000 drawings for the guidance system of a medium sized missile.

Improved packaging of liquid fuels is prompting more serious consideration of liquids as opposed to solids for missiles at both ends of the rocket spectrum. Development of an efficient cartridge-type loading for liquid fuels may replace solids in smaller birds. Reports say liquids may be considered for several of the air-to-air and air-to-ground missiles. The ability to control thrust of liquids keeps liquid fuel in the longer-range missile despite the fueling process. RMI is believed to be spearheading development in this field.

Postscript: There is no space for the Senate Space Committee on Capitol Hill—it is temporarily holding forth in the Home Owners Loan building.



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While this was a difficult problem indeed, it is typical of the tough assignments that are routine with Brunswick. The one-piece radome-boom of the Q5, wound by the top secret Strickland "B" process, exclusive with Brunswick, substantially contributes to the enormous savings of military dollars made possible by the unique Q5 recovery system.

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VOL. 3 NO. 6

MAY, 1958

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Top Personnel Shortage Worries Industry

Government officials concerned as rising appropriations force greater work-load on small staffs of management-scientists

by William O. Miller

Of growing concern to both the military and industry is the increasingly limited number of men available who have the technical knowledge and managerial skill needed to develop and produce missiles.

Top levels in the Department of Defense are well aware that increasing the work-load of qualified personnel now on the payroll can result in a diminishing return, despite larger and larger appropriations by Congress.

As one remedy, the suggestion has been made that Advanced Research Projects Agency, or a similar agency, be empowered to screen new projects and developments in already active programs. The screening not only would be in regard to defense requirements, but also would consider available personnel and facilities.

Secretary of Defense McElroy, in a recent speech before the National Press Club, said that approximately 50% of the qualified technical personnel now available are already working on military or government-backed projects.

Those who know say this availability of scientists and engineers is about the limit of those who can be paid and persuaded to work on such projects—at least without a specified draft program.

Of slightly less concern but still important, is the pool of managerial talent which can be drawn upon to handle the special problems and considerations inherent in a rapidly expanding missile industry.

One Navy spokesman said, "The happy combination of managerial and technical ability that can undertake large rocket projects, particularly in the solid propellant field, is rarer than you might think."

Obviously, this was said in reference to possible siphoning off of personnel presently employed on programs such as *Polaris,* for use in development of other large solid propellant vehicles like *Minute Man, Pershing* and others.

Continuing, the Navy spokesman said:

"If you don't think this is true, just read the want-ad pages of our major metropolitan newspapers after a contract is let for research and development. You will see how the various companies are forced to bid for personnel already employed by similar orgainzations.

"In the national interest, future proposals for large rockets must be considered not only with an eye to overall defense planning, but also in view of the personnel and facilities available to develop such projects."

Knowledgeable personnel is further limited in military research and development agencies, and in the ranks of sub-contractors whose contributions can make or break a project. At the moment, there are some 48 missile projects in the works or in development.

• **How many and who**—A recent unofficial survey of key personnel in solid propellant and allied rocketry shows the total employed and where they are located:

Service program management and planning groups:

Navy—E. Mitchell (BuOrd)
R. Roberts (ONR)
Capt. L. Smith (Special Projects)
Cmdr. W. J. Corcoran (Special Projects)
Army—R. C. Swann (Redstone)
C. M. Hudson (Army Ordnance)
J. A. Chalmers (Army Ordnance)
N. Klein (Army Ordnance)
J. W. Dawson (OOR)
USAF—W. C. Fagan (WADC)
Maj. W. Henderson (ARDC)
Col. A. N. Hall (BMD)
Col. P. G. Atkinson (OSR)

Top-level non-service technical management in charge of large active programs:

A. Aerojet—R. D. Geckler
Thiokol—H. Ritchey
Grand Central—C. Bartley
Phillips Petroleum—E. Fiock
Olin-Mathieson (Reaction Motors)—J. J. O'Neil, G. Miller, Dr. Herndon
Atlantic Research—A. C. Scurlock
Standard of Indiana—Wayne Proell
Ramo-Wooldridge—B. Adelman
B. Allegany Ballistics Laboratory—C. D. McKinney, R. Winer
Jet Propulsion Laboratory—P. L. Nichols, Jr., F. E. Goddard
Rohm and Haas at Redstone—A. R. Deschere, H. M. Shuey, W. D. Niederhauser
Applied Physics Laboratory—W. Avery
C. NOTS—H. Hunter, W. McEvan
NPF—S. Skolnik
NOL—P. M. Fye
Redstone—R. C. Swann
Picatinny—A. Frye, C. S. Davis, A. Lopresti

Scientists with broad background in solid propellants who contribute on a "consultant" basis:

W. Avery	(APL)
L. G. Bonner	(Hercules)
F. T. McClure	(APL)
B. Crawford	(Minnesota)
F. H. Westheimer	(Harvard)
Frank Long	(Cornell)
Wendall Jackson	(DuPont)
A. M. Ball	(Hercules)
G. Kistiakowsky	(Harvard)
H. W. Emmons	(Harvard)
R. H. Olds	(NOTS)
S. I. Cheng	(Princeton)
A. J. Stosick	(Union Carbide)
D. Altman	(Aeronutronics)
B. H. Sage	(Calif. Inst. Tech.)
John Kincaid	(Rohm & Haas)
A. L. Antonio	(GT & R)

. . . personnel shortage worries industry

E. T. McBee (Purdue)
Clayton Huggett (Rohm & Haas)
M. J. Zucrow (Purdue)
B. Lewis (Combustion & Explosives Research, Inc.)

Persons in immediate contact with specific areas of propellant work:

A. Propellant development
- Polyurethane composites—K. Klager (Aerojet), P. L. Nichols (JPL)
- Thiokol composites—R. S. Arrandale, J. W. Wiggins (Redstone), E. Sutton (Thiokol)
- Polybutadiene-acrylic acid, copolymer composite—E. Japps (Goodrich)
- Plastisol composites—L. Weil (Atlantic Research)
- Ammonium nitrate composites—W. A. Proell (Standard Oil of Indiana), E. Fiock (Phillips Petroleum)
- Nitropolymer composite—K. Klager (Aerojet)
- Double base (high energy)—A. Camp (NOTS), R. Preckl (ABL)
- Petrin-double base—W. D. Niederhauser (Rohm & Haas)
- Metal additives—K. Rumbel (Atlantic Research)
- Boron compounds—Eugene Miller (Olin-Mathieson), E. A. Weilmuenster, (Olin-Mathieson)
- N-F compounds—W. D. Niederhauser (Rohm & Haas), W. H. Pearlson (Minnesota Mining & Mfg.)
- New Ingredients—Charles J. Marsel (NYU), W. S. McEwan (NOTS), P. O. Tawney (U.S. Rubber), E. A. Weilmuenster (Olin-Mathieson), W. D. Niederhauser (Rohm & Haas)

B. Theory and design
- Combustion instability—(see list of participants in recent DOD meeting on combustion instability)
- Deflagration-to-detonation transition—C. L. Zernow (Aerojet), H. M. Shuey (Rohm & Haas), J. E. Ablard (NOL), D. Altman (Aeronutronics), M. A. Cook (Univ. of Utah)
- Theory and thermochemical—K. E. Rumbel (Atlantic Research), A. O. Dekker (Aerojet), P. L. Nichols (JPL), R. Steinberger (ABL), H. M. Shuey (Rohm & Haas), D. Altman (Aeronutronics), W. S. McEwan (NOTS), A. S. Gordon (NOTS), F. A. H. Rice (NPF), F. T. McClure (APL), J. A. Rottenberg (Univ. of Minnesota), R. H. Olds (NOTS)
- Ignition—J. H. Wiegand (Aerojet), G. J. Bryant (NOL), J. C. Brier (Univ. of Michigan), J. E. Pelham (Thiokol)
- Ballistic design—J. I. Schaffer (JPL), R. Winer (ABL), J. W. Wiggins (Thiokol), K. E. Rumbel (Atlantic Research), E. W. Price (NOTS), H. M. Shuey (Rohm & Haas)

C. Physical Properties—F. J. Lavacot (NOTS), P. E. Newman (ABL), E. H. Lee (Brown Univ.), P. J. Blatz (Aerojet), plus members of JANAF Physical Properties Panel

D. Processing methods—F. J. Lavacot (NOTS), J. W. Wiggins (Thiokol), K. Klager (Aerojet), E. Fiock (Phillips Petroleum), E. R. Csanady (NPF), G. F. Cramolini (Minnesota Mining & Mfg.)

Even though the missile personnel shortage now applies only to the solid propellant field, a breakthrough in this field can result in broad across-the-board planning changes. Similar shortages exist in other fields. The personnel problem will continue to be acute as progress is made in other experimental projects.

Missile Experts Tell Congress How To Beat Reds In Space

Congress gingerly dipped a toe into space last month, liked the feel of it, and dived right in.

However, the new House Committee on Astronautics and Space Exploration, which began its first series of public hearings April 15, clearly was not on familiar ground. Even though Congressmen are not known for kid-gloving witnesses, the new Space Congressmen made it plain they were trying to learn.

The Caucus Room, which housed the first two weeks of hearings, became an informal classroom with an impressive array of missile and space experts as instructors.

Instructors included such men as Dr. Wernher von Braun, technical director, ABMA; Maj. Gen. John B. Medaris, chief of the Army Ordnance Missile Command; and Dr. Fred Whipple, director of the Smithsonian Astrophysical Observatory.

Sample questions asked by the Congressman were, "Are the present thrust problems on rockets based on the same fundamental principles as Goddard's? Are the Russians using these same principles? How far up does space start?"

The committee has 11 bills before it—all almost identical—to establish a National Aeronautics and Space Agency.

• **Teeth needed**—The majority of witnesses favored a full-time, smaller board "with teeth," rather than the 17-member advisory board recommended in the Administration bill. Under this bill the board would be required to meet only four times a year and would function much like the NACA, which the new agency would absorb. Witnesses pointed out that their roles would be different; that whereas NACA conducted experiments, it was the DOD which negotiated the contracts based on those experiments.

Space Committee Members

Members of the House Select Committee on Astronautics and Space Exploration:

Chairman, John W. McCormack (D-Mass.); Overton Brooks (D-La.); Brooks Hays (D-Ark.); Leo W. O'Brien (D-N.Y.); Lee Metcalf (D-Mont.); William H. Natcher (D-Ky.); B. F. Sisk (D-Calif.); Joseph W. Martin, Jr. (R-Mass.); Leslie C. Arends (R-Ill.); Gordon L. McDonough (R-Calif.); James G. Fulton (R-Pa.); Kenneth B. Keating (R-N.Y.); Gerald R. Ford, Jr. (R-Mich.).

Members of the Senate Special Committee on Space and Astronautics

Chairman, Lyndon B. Johnson (D-Texas); Richard B. Russell (D-Ga.); Theodore Francis Green (D-R.I.); John L. McClellan (D-Ark.); Warren G. Magnuson (D-Wash.); Clinton P. Anderson (D-N.M.); Stuart Symington (D-Mo.); Styles Bridges (R-N.H.); Alexander Wiley (R-Wisc.); Bourke B. Hickenlooper (R-Iowa); Leverett Saltonstall (R-Mass.); John W. Bricker (R-Ohio); Karl E. Mundt (R-S.D.).

NASA will have cognizance not only over research and development but will have power to let contracts.

Consensus of witnesses: Congress would do better to look to the Atomic Energy Commission, which has a powerful full-time five-member board, as a model for the new agency.

The main point put across by witnesses was the urgency of overtaking Russia's lead. They said the United States should:

(1) Make a thorough study of European educational systems as a basis for overhauling our own.

(2) Cut the lag in putting new developments into production. Adm. H. G. Rickover, Assistant Chief, Nuclear Propulsion, Bureau of Ships, said Russia's lead time, from the inception of an idea until it rolls off the assembly line, is "one-half of ours."

(3) Keep R&D teams intact after projects are completed.

(4) Once the ball is rolling on a space program, keep up a sustained effort, based on planning as much as 15 years ahead.

(5) Get foreign technical documents translated faster and into the hands of the scientists. Adm. Hayward pointed out that the Russians are spending $1 billion annually translating "every technical document that comes out of the Free World."

(6) Keep the new agency from over-entanglement in unnecessary security classification.

(7) Pay government scientists more.

(8) Keep the new space agency independent of the military. Adm. Rickover stressed that civilian-run projects were always "more efficient" than those run by the military. He added that he was convinced the *Nautilus* atomic submarine program could have developed more quickly under civilian control.

(9) Spend more money on basic research.

• **Schriever appears**—On the day following the Air Force launching of a *Thor-Vanguard* combination from Cape Canaveral, Maj. Gen. Schriever, head of the Air Force's Ballistic Missile Division, ARDC, appeared before the committee (see also p. 70).

The Air Force missile chief told the committee that projects should remain where they are, even after the establishment of a space agency. He recommended that NACA should be the block upon which the proposed new agency will be based. He also said he favored from three to five military men on the proposed 17-man committee.

The current hearings are expected to continue into the middle of May.


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Biggest Missile Industry Meeting Yet...

Congressman Moss; Douglas; Kimball; Cook; Crosby; Kantrowitz to chair panel discussions in Washington June 4–6. First Goddard Memorial Dinner will conclude conference.

FUTURE OF THE NATION'S missile-space industry will be analyzed in Washington next month at the First National Missile Industry Conference, sponsored by the American Rocket Society's National Capital Section and the National Rocket Club.

Advance registrations for the three-day meeting, June 4-6 at the Mayflower Hotel, indicate more than 1,000 industry-government leaders will attend. Six panels are scheduled: Contracting and Negotiation, Government Roles and Responsibilities, Freedom of Information, Research and Development, Commercial Markets, and Business Forecasting.

Dr. Robert H. Goddard Memorial Dinner, honoring the nation's first rocket pioneer, will conclude the conference. Industry awards will be presented for special contributions to the advancement of missilry, rocketry and astronautics.

For the first time, the National Missiles and Rockets Award—similar to aviation's famed Wright and Collier Trophy Award—will be made to the person or individuals who in 1957 made the most outstanding contribution to the U.S. rocket, missile or astronautics program. The award will be presented by Wayne W. Parrish, president, AMERICAN AVIATION PUBLICATIONS, Inc., and publisher of m/r magazine.

• **Program**—Donald W. Douglas, Jr., president, Douglas Aircraft Co., Inc., will chair the opening session on Contracting and Negotiation. Moderator will be Warren R. Smith, assistant to the president, Fairchild Engine & Airplane Corp. A "Space Age" luncheon will be held honoring the U.S. satellite teams.

In the afternoon, Gen. Orval R. Cook, president, Aircraft Industries Association, will chair the Government Roles and Responsibilities panel. A reception will be held that evening in honor of the Army Ballistic Missile Agency and the Naval Research Laboratory space satellite teams.

On the second day, Rep. John E. Moss (D-Calif.), will preside over the Freedom of Information panel. Dr. Harold Wooster, director of Research Communication, Air Force Office of Scientific Research, ARDC, will serve as moderator.

In the afternoon, Dr. Arthur R. Kantrowitz, director, AVCO Research Laboratories, will be chairman of the Research and Development panel. Moderator will be Thomas Wilcox, president, Thomas Wilcox Associates, Inc. A reception will be held that evening in honor of Mrs. Esther C. Goddard, widow of Dr. Goddard.

The last day's session on Commercial Markets and Business Forecasting will be chaired by Dan Kimball, president, Aerojet-General Corp., and J. W. Crosby, president, Thiokol Chemical Corp.

• **Ladies' Too**—Woman's Auxiliary of ARS' National Capital Section will have a special wives' program. Each discussion panel will average six members.

Among those scheduled to participate are: RAdm. John E. Clark, deputy director Advanced Projects Research Office; F. O. Detweiler, president, Chance Vought Aircraft, Inc.; Joachim H. Kauffmann, president, Diversey Engineering Co.; H. L. Thackwell, Jr., vice-president, Grand Central Rocket Co.; Kenneth Ellington, Telecomputing Corp.; Dr. Richard Kershner, Applied Physics Laboratory, Johns Hopkins University; Col. John R. V. Dickson, director, Development, ARDC.


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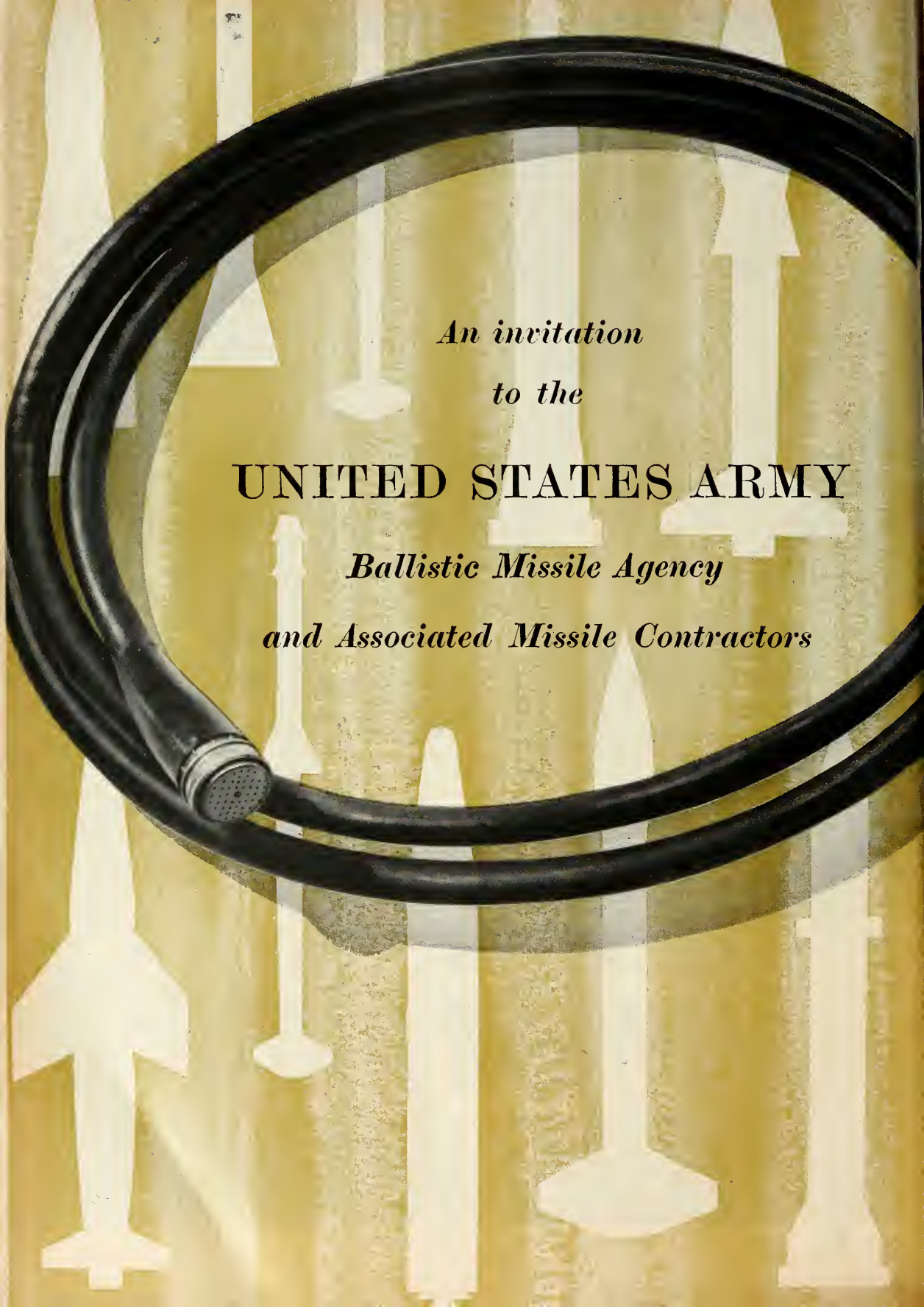


An invitation

to the

UNITED STATES ARMY

Ballistic Missile Agency

and Associated Missile Contractors

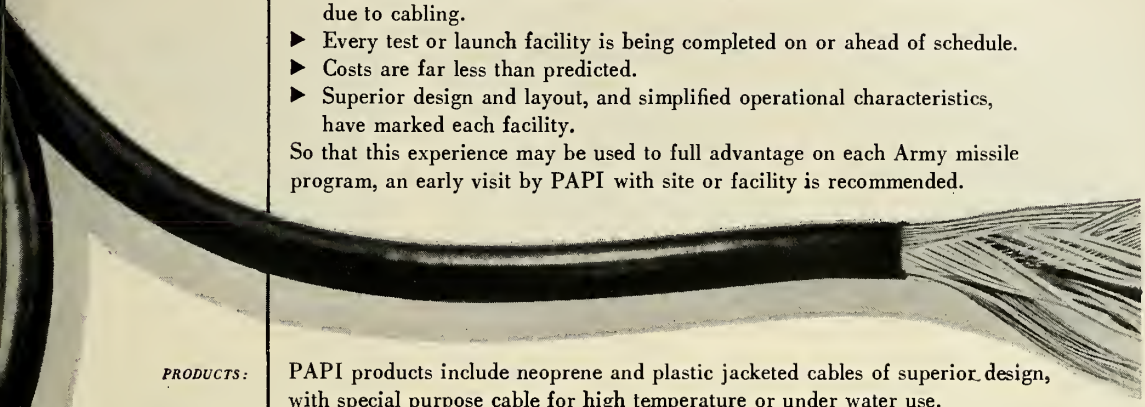
INVITATION: This is an invitation to utilize the missile systems engineering services of Pacific Automation Products, Inc., on current and upcoming Army missile programs.

QUALIFICATIONS: PAPI is an organization of 700 cable systems specialists. Over 150,000 square feet of floor area are now devoted to engineering, manufacturing, inspection, with production capacity to meet any workload. Because PAPI cables have been used on such Army missile programs as the Sergeant, Hawk, and LaCrosse, you know our product to be reliable.

Here is the record of PAPI performance on one of this nation's major missile programs:

- Over 20,000 cable components are now in service, with no malfunctions due to cabling.
- Every test or launch facility is being completed on or ahead of schedule.
- Costs are far less than predicted.
- Superior design and layout, and simplified operational characteristics, have marked each facility.

So that this experience may be used to full advantage on each Army missile program, an early visit by PAPI with site or facility is recommended.



PRODUCTS: PAPI products include neoprene and plastic jacketed cables of superior design, with special purpose cable for high temperature or under water use.

SERVICES: PAPI offers the following services in the cabling and activation of missile test and launch facilities: *Systems Design*—working from schematics, PAPI design engineers will determine every conductor that is needed to link block houses, control centers, terminal rooms, and stands or platforms. Cables are designed to effectively accommodate these conductors, and include break outs, connectors, and accessories. *Systems Fabrication*—cable assemblies leave our plant in ready-to-install condition, with rigorous quality control procedures governing every step of the fabrication process. *Systems Installation*—PAPI's experienced personnel and proven methods are utilized in field installation of all inter-unit cabling, instrumentation, recorders, transducers, controls, consoles, and accessories. *Systems Checkout*—PAPI specialists checkout all circuits for conformity to specifications, confirm the operation of each instrumentation system, and validate the fire and launch control functions. *Systems Documentation*—working drawings of the entire installation are supplied in approved form.

CONCLUSION: PAPI's engineering staff includes men with outstanding experience in every pertinent phase of the missile business. It is no accident, therefore, that we are the "take charge" sort of people who can take full responsibility for providing the services described in this message. We hope that you will accept this invitation and plan to utilize PAPI's great practical knowledge and experience in Army missile facility cabling and activation.

Arthur P. Jacob

ARTHUR P. JACOB, EXECUTIVE VICE PRESIDENT

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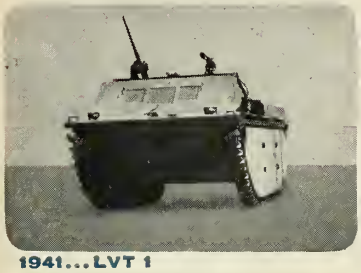


1941...LVT 1
Amphibious Personnel-Cargo Corrier

1942...LVT (A) 1
Amphibious Armored Assault Vehicle

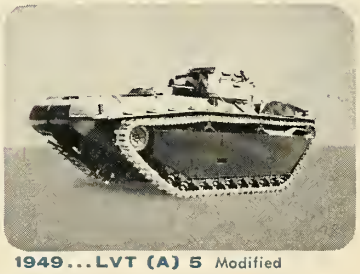
1942...LVT 2
Amphibious Personnel-Corgo Corrier

1943...LVT (A) 2
Amphibious Armored Personnel-Corgo Corrier

1944...LVT 4
Amphibious Personnel-Corgo Corrier

1944...LVT (A) 5
Amphibious Armored Assault Vehicle

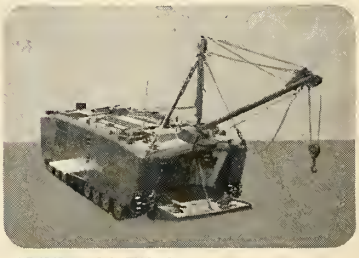
1945...LVT 4 Lightweight
Amphibious Personnel-Corgo Corrier



1949...LVT (A) 5 Modified
Amphibious Armored Assault Vehicle

1951-1958...M59
Armored Personnel Corrier

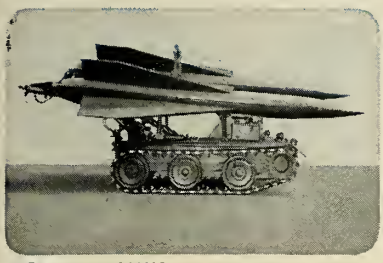
1954...LVT P6
Amphibious Armored Personnel-Corgo Corrier



1955...LVTR-1
Modified Vehicle for recovery duty

1957...M-84
Mortor Corrier Vehicle

HANDLE MISSILE LAUNCHER PROGRAMS



1957...HAWK
Mabile laader Vehicle

1958...THOR
Transparter-erector Launching Mount & Power Cantrol Trailer

FMC's development of ground support equipment for major missile projects stems from over 17 years experience in producing mobile surface equipment for the Armed Forces

Since 1941, FMC has designed and built more types of military-standardized tracked vehicles than any other company in America. This extensive and versatile background in the field of mobility can be applied to your missile ground support project.

FMC is uniquely qualified to handle every phase of the job from design concept through development, engineering, and production on any size project. Long familiarity with military requirements enables FMC to approach basic design with standardization in mind. With fully integrated facilities devoted exclusively to the production of defense equipment, contract delivery requirements are met – on schedule.

Do what others have done. Provide for the over-all success of your missile system, by contacting FMC at the very beginning of your program. This will insure perfectly coordinated development and delivery of required ground support equipment. Contact us today for more information.

Creative Engineers: Find stimulating challenge at FMC's Ordnance Division

FMC'S MISSILE EQUIPMENT PROJECTS:

Mobile looder vehicle — **HAWK**	Transparter-erectar & power cantrol trailer — **THOR**	Trocked prime mover — **REDSTONE**
Shipping ond storage containers — **NIKE-HERCULES**	Erector-launcher and Decontaminatian system — **BOMARC**	Transporter-erectar & vertical access tower — **NAVAHO**

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...THE TRULY REUSABLE FITTING FOR FLUOROFLEX®-T HOSE

adjusts 360° with no loss of grip

BASIC GRIP NEVER LOOSENS

Socket and unique lockring in SEAL-LOCK fitting exert unshakable grip on hose. Once applied, this hold need never be disturbed when adjusting elbows. Lockring keeps initial grip strength no matter how much or how often elbow is swiveled... *an exclusive* SEAL-LOCK *safety feature*... extra blow-off insurance.

STAYS LOCKED AND LEAKPROOF

When tightened, SEAL-LOCK fittings are triple-locked and dynamically sealed. Left hand safety thread cannot accidentally loosen during installation of hose assembly. Lock nut effect prevents loosening by vibration during operation.

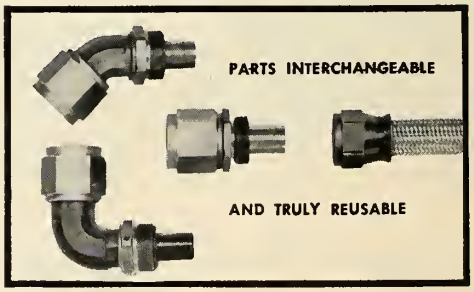
COMPLEMENTS INTEGRITY OF FLUOROFLEX-T HOSE

Fluoroflex-T is a chemically inert compound of Teflon® developed and patented by Resistoflex. It assures completely reliable performance in aircraft and missile systems... for protection of equipment and human life.

PARTS INTERCHANGEABLE — TRULY REUSABLE

Ideal for mock-up work. Substitute an elbow for a straight nipple or vice versa. Permits quick repair of damaged nipples. No need to change hoses or touch socket to change couplings. Parts are hardened . . . can be reused again and again. Send for Bulletin RF-1.

**Pat. applied for*
® Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
® Teflon is DuPont's trademark for TFE fluorocarbon resins.



Originators of high temperature fluorocarbon hose assemblies

Resistoflex CORPORATION

Roseland, New Jersey • Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Tex.

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Rear Adm. Raborn, USN, Navy Special Projects Office, with *Polaris* in background.

Polaris Details Emerge

On April 11, over 1,000 people converged on Washington's Sheraton Park Hotel for the Navy League's Seapower Symposium, celebrating the 58th anniversary of the launching of the first submarine, the SS Holland. The big news break in the missile business was the unveiling of the Navy's Fleet Ballistic Missile, *Polaris*.

A full-scale model of *Polaris* was displayed on the hotel's ballroom stage. With a height of 26 ft. 6 in. and a diameter of 54 in., *Polaris* is a two-stage solid propellant weapon with an ultimate design range of 1,500 nautical miles.

Polaris is designed to be carried in lots of 16 in specially-designed nuclear-powered submarines. It will be launched from under water by compressed air, with its rocket engine designed to ignite when the missile is airborne.

In an address made during the banquet, Rear Admiral W. F. Raborn, USN, Director, Special Projects Office of the Navy Bureau of Ordnance, said, "I firmly believe that we will have actual operational missiles in 1960."

With the marked success of the *Polaris* development program, it seems virtually certain that the limiting factor in this case is the time needed to produce and fit out the first submarines —rather than development of a successful missile. *Polaris* submarines are now already on the ways, with work proceeding under a wartime schedule of overtime.

Some details of the *Polaris* missile which were not officially released, but which became apparent in studying the model itself and movies shown of the test flight vehicles are listed below.

Polaris will be a two-stage bird. The first stage engine is 53 in. in diameter and 110 in. long. The second stage engine, which will provide both range and vernier control, is 53 in. in diameter and 47 in. long. This last stage reportedly will have thrust reversers for instanteous separation and cut-off.

Polaris engines will fire through multiple nozzles. Each nozzle will be equipped with a cylindrical jetavator for precision control. *Polaris* is shown as being completely finless. Admiral Raborn said that the new fuel already developed for *Polaris* constitutes a major technological gain.

Initially, *Polaris*' range may be limited by the strength of the thinwall motor casings. Reportedly, these have an initial ultimate yield strength of about 184,000 lb. psi, and with this strength the range will be somewhat under 1,000 miles. However, at 220,-000-to-240,000 psi, the full range of 1,500 miles will be realized.

Several companies, including Aerojet-General (*Polaris* engine contractor) and Thiokol Chemical (still a contender for a *Polaris* engine contract), are experimenting with stronger motor casings. Tolerances on these engines, incidentally, are on the order of plus-or-minus two-thousandths of an inch on the inside diameter with a wall thickness of less than 70/1000 in. The engine chamber pressure is about 1,000 lb. psi.

No details have been released as to how many *Polaris* missiles will finally be ordered, but it could be around 1,000. There's talk of building 40 *Polaris*-launching submarines which, multiplied by 16 missiles, comes out to 640 missiles. Add those needed for test and training and the initial production order totals 1,000.

In production, each missile will cost $500,000 each, making them the least expensive missiles of comparable range in the U.S. arsenal. This "savings," however, will be partially offset by the cost of the launching vehicle—the $80 million *Polaris* submarine and the submarine's Shipboard Inertial Navigation system.

Maj. Simons Volunteers for First Manned Rocket Ride

Maj. David G. Simons has volunteered his services for the first manned rocket flight into space, m/r has learned exclusively.

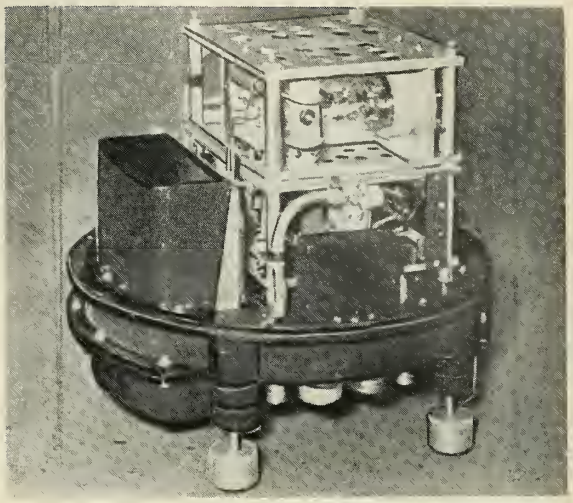
Simons, who set an altitude endurance record last August with a 32-hour-102,000-foot balloon flight, volunteered four months ago when the Army Ballistic Missile Agency first proposed sending a manned capsule spaceward. The Department of Defense has not yet given its approval.

The proposal was recently made public on the opening day of hearings of the new House Committee on Astronautics and Space Exploration. Dr. Wernher von Braun, Director of ABMA's Development Operations Division, told the Congressmen that the missile would take a man 150 miles into space and bring him back safely.

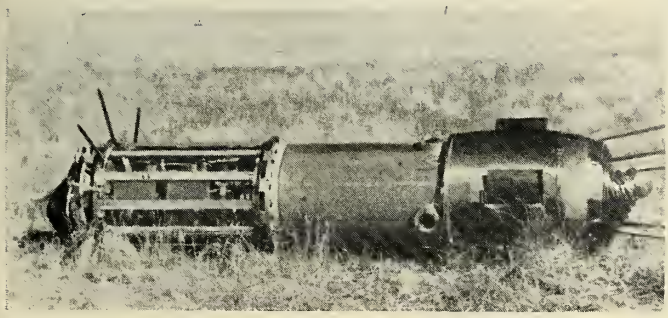
The pilot would be sealed in the missile's nose cone, which would separate shortly after burnout, and the capsule would then go through the apex of the trajectory.

During the five minutes the vehicle is in a gravity-free state, the pilot could "make all kinds of observations," von Braun said. The vehicle would land by means of a parachute and drag brakes. The entire flight would last ten minutes.

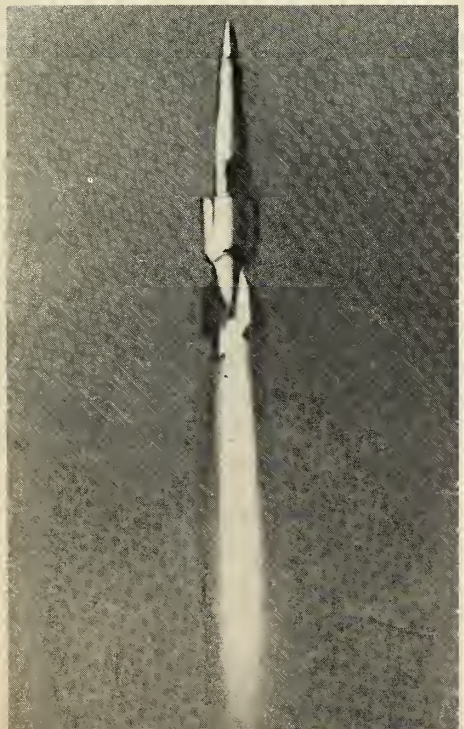
Soviet Reveals IGY Vehicles and Instrumentation

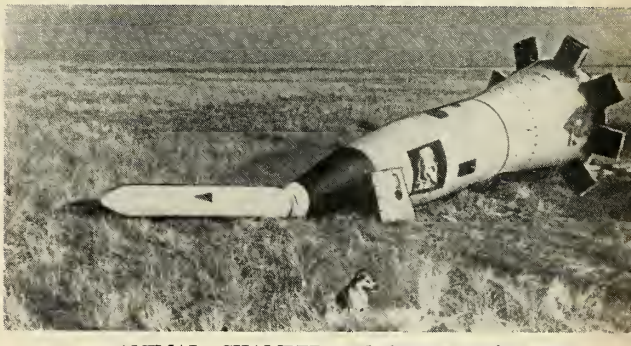


INSTRUMENTS installed in Soviet IGY rocket include ionization and magnetic manometers and above dispersion radiofrequency interferometer for the precise measurement of wave-lengths. The same type of electronic equipment was in Soviet *Sputnik* II.



RECOVERED instrument container of an IGY rocket is shown after being successfully recovered from an experimental flight. At the peak of the rocket trajectory, the container was separated and parachuted 132 miles to earth.

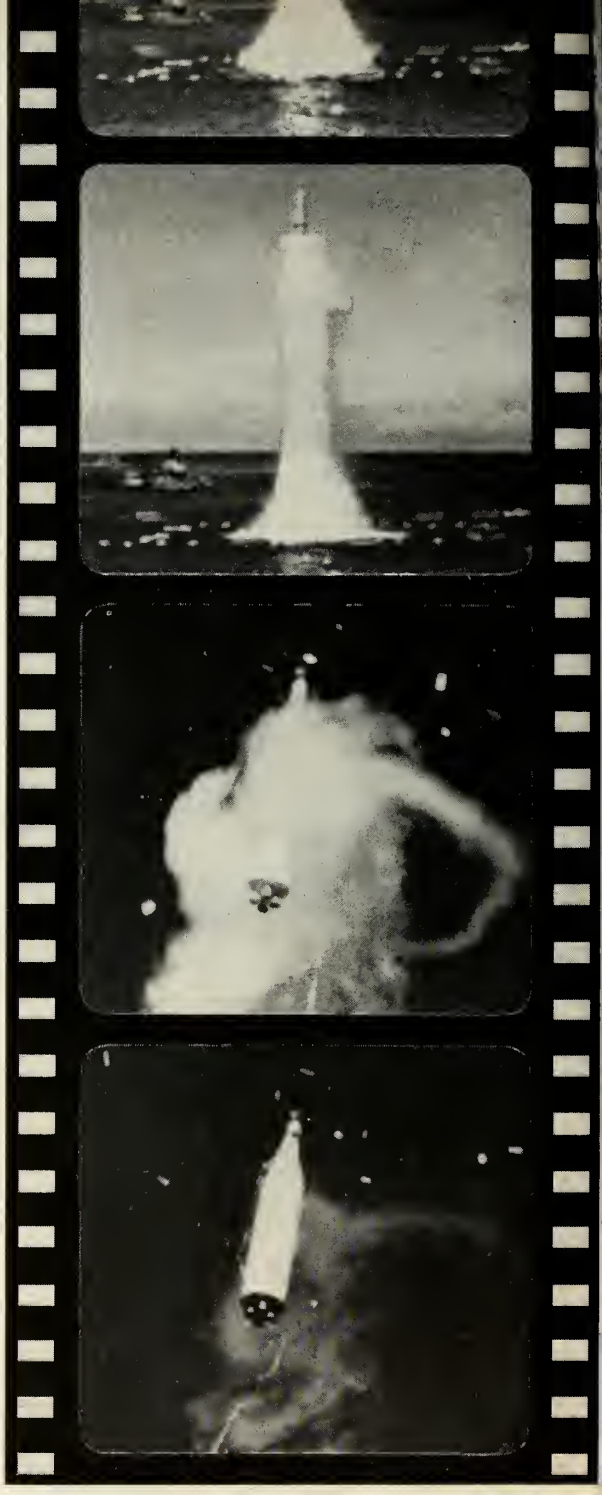




ANIMAL CHAMBER and instrumentation compartment of another Soviet rocket after being parachuted to earth from extreme altitudes. The dog in the foreground, apparently heavily retouched, has emerged from the recovered payload section.

LAUNCHING of a research rocket by the USSR during recent experiments. Projecting from the sides of the vehicle are the instrument compartments which separate and parachute to the ground.

Out of the Sea...



Symbolizing the Navy's future in underwater ballistic missile warfare, a *Polaris* FBM test vehicle erupts in a mighty geyser of water from its missile container anchored several feet below the surface of a Pacific test site. The *Polaris* is ejected vertically from its underwater container by compressed air in much the same manner as a torpedo. Note the four nozzles of the first stage, in the last photo.

Navy Unveils Bullpup At El Centro

The Navy has taken the wraps off the first air-to-ground guided missile especially designed to provide non-nuclear fire support to ground troops and tactical targets.

The missile was shown statically at the third annual Naval Air Weapons Meet in El Centro; although an on-again, off-again demonstration firing was cancelled. Apparently, the cancellation was due to bugs in the control system of one of the planes scheduled to participate, and not in the missile itself.

Another first which *Bullpup* can claim is that it is so designed as to practically eliminate the usual elaborate ground support system of maintenance and training. Due to its simplicity, the supersonic solid-propellant missile can be checked out at the factory; placed in storage up to six months; and have its three parts assembled and mounted on an aircraft in five minutes by a three-man crew.

Bullpup has been termed by one Naval spokesman as a "round of ammunition". The 10-foot, 600-pound missile can carry a variety of 250-pound bombs with a 40% greater punch than conventional 250-pound bombs delivered by conventional dive bombing.

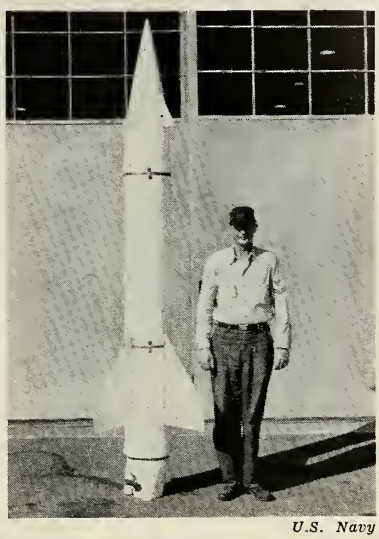
Bullpup is in line of sight weapons controlled by a direction button in the cockpit of the firing aircraft. The control gives up-down, right-left commands. By flying the aircraft, the pilot simultaneously flies the missile until zeroed-in on the target.

Guidance is by radio link, and it is assumed that tracking is by pyrotechnic flares or the like in the boattail. Movable snap-in canards on the nose control yaw and pitch during flight.

There is no homing system, and as a result, Captain James G. Sliney, assistant director of the Guided Missiles Division in the office of the Chief of Naval Operations, reported that *Bullpup* would probably be difficult for the enemy to jam.

The 300-pound solid grain rocket motor was first developed by Allegheny Ballistics, and is now being made by Aerojet General. *Bullpup* went into production with letting of an $8-million contract to the Martin Company in January.

Fleet delivery is scheduled for early fall. Naval spokesmen declined to give exact numbers, but they said deployment would be "good-sized". Due to its simplicity in mounting and firing, *Bullpup* will be ready for use immediately upon arrival in the Fleet.



U.S. Navy

STANDING ABOUT four feet higher than this 6′ 3¼″ tall sailor, *Bullpup* has a radio receiver in nose section, and carries any of several standard 250-pound bombs in center section. Aero-jet General builds the solid-grain motor.

Pilots who have been testing the missile have praised it highly for accuracy. A first test by one pilot resulted in a hit on a four-inch target at a firing range of two miles.

The Navy has been testing the bird on FJ4 Furies and A3D Skynights. First tests were on the prop-driven AD6. The Navy presently loads up to six *Bullpups* per plane.

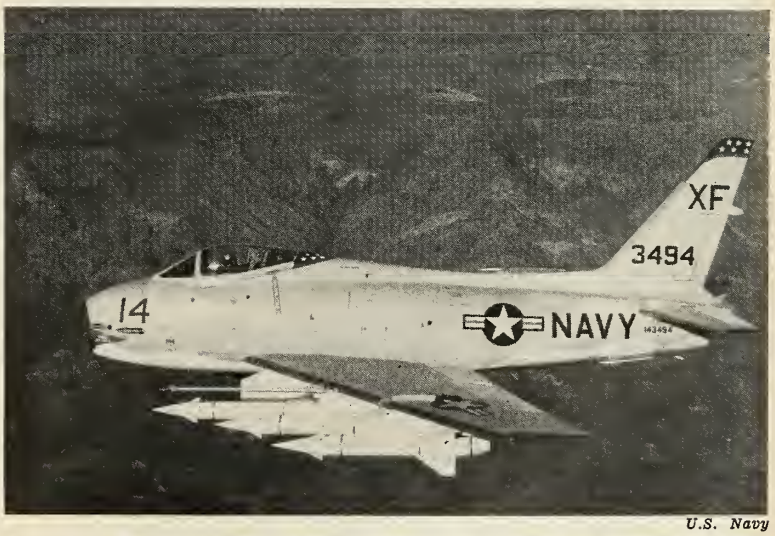
The Air Force has tested *Bullpup* on several aircraft including the F94 Starfire. Testing has been somewhat deterred due to the fact that *Bullpup* is stowed externally and does not have an all-weather guidance system.

Indications are that the guidance system will remain as it is for the present, although the missile and its warhead are due for further development in extended range, voice guidance and more accurate target acquisition.

Bullpup was first conceived during the Korean War, in which Navy and Marine fliers flew some 40% of the combat missions, particularly in close ground support and interdiction. Enemy ground fire, rugged terrain, and inclement weather resulted in heavy losses during low-level attacks.

This newest addition to the interdiction arsenal provides the Navy and Marines, both of whom will employ the missile, with the most potent non-nuclear weapon to date for use in both land-based and carrier-borne aircraft.

First mentioned a year ago at the Aviation Writers Association meeting in St. Louis, the *Bullpup* demonstration firing will probably be at Corpus Christi during the AWA meeting in Houston this month.



U.S. Navy

BULLPUP, **the Navy's solid propellant "Missile With a Bomb," is mounted on pylons of the FJ4 Fury. Supersonic at launch while aircraft is in dive toward target, *Bullpup* is guided visually by observations of pyrotechnic flares in boattail. The aircraft sends directional commands by radio, preventing jamming. Four snap-in canards on nose are actuated by up-down, right-left commands from cockpit. High reliability has enabled the Navy to eliminate costly testing and maintenance.**

. . . news and trends

Future Earth Satellites To Be Self-Serviced

Future satellites will have self-servicing devices remotely controlled from the ground, the House Space Committee was recently told.

Dr. Fred Whipple, Director of the Smithsonian Astrophysical Observatory, described what he called a "telepuppet" built into a satellite which could "duplicate what the operator's hands were doing on the ground" through telemetry.

Dr. Whipple pointed out to the House Astronautics and Space Committee that a similar device on a minor scale is now in use in "hot" laboratories—those using radioactive materials.

The satellite's robot would enable the operator to see problems as they arise, and then solve them.

"When such devices are well developed," Whipple told the committee, "they will have multitudinous practical purposes on earth. I can see the time when the telepuppet will do our dangerous mining underground . . . and also deep sea operations."

Hollow Titanium Shapes Now Cold-Extruded

The first successful cold extrusion of hollow titanium shapes—a major step in the development of economic methods for producing hollow aircraft parts—was reported to the Manufacturing Methods Branch of the Air Materiel Command this week by Battelle Memorial Institute. The work was performed under a development contract awarded by AMC's Manufacturing Methods Branch.

Cold extrusion of hollow shapes is the latest accomplishment resulting from studies conducted during the past two years for the Air Force by the Columbus, Ohio research center. This research, which has taken cold extrusion of titanium from a laboratory concept to the threshold of commercial application, was conducted by the institutes' light metals staff under the direction of Paul D. Frost and Alvin M. Sabroff. This was the same team that first reported success in the development of a technique for hot extrusion of titanium, also while conducting research for the Air Force.

One unique aspect of this cold extrusion research was the use of a 700-ton hydraulic press.

In cold working titanium for the Air Force, Battelle metallurgists pro-

duced hollow titanium shapes by forward and backward extrusion. One-and-one-half inch diameter slugs of unalloyed titanium were backward cold extruded in a three-story high hydraulic press to make cups up to three inches long with wall thickness down to 0.22 inch. This is a 50 percent reduction in thickness.

In forward extrusion studies, cup-shaped billets with 1½-inch outside diameters and 7/8-inch inside diameters were cold-extruded into cylinders with wall thicknesses down to 0.15 inch. Surface finishes were 30 to 60 micro inches, equivalent to a smooth turned finish. In addition to providing a finished surface, cold extrusion improves mechanical properties of unalloyed titanium. Increases in tensile strength of 30 percent have been obtained.

Air Force, Army Begin Missile Systems Training

The Air Force has announced start of a comprehensive missile system training program for the *Atlas, Titan, Thor, Jupiter, Snark, Mace-Matador and Bomarc.*

Air Force training will be at three command bases: Chanute Air Base, Ill.; Lowry Air Base, Colo.; and Amarillo Air Force Base, Texas. Two additional bases, Keesler in Mississippi and Sheppard in Texas, are scheduled for training programs in the near future.

The Army Ordnance Guided Missile School, Redstone Arsenal, will begin classes on the 20-mile range surface-to-surface missile, *Lacrosse.* Some 32 students are enrolled in three *Lacrosse* classes and will receive instruction in maintenance supervision, guidance system repair, and electro-mechanical repair.

SAC will be responsible for crew training in the *Atlas, Titan, Thor, Jupiter* and *Snark* systems. TAC will have crew training in the *Matador-Mace,* and ADC will be responsible for *Bomarc.* Courses will run from two to 30 weeks.

m/r Columnist Receives 2nd Award in Two Months

The second honor in two months was bestowed on Dr. Hubertus Strughold, dean of space medicine and m/r columnist.

Dr. Strughold was presented with the Theodore C. Lyster Award at the recent Aero Medical Association meeting in Washington, D.C. "for his outstanding achievements in the field of

aviation and space medicine."

Formerly advisor for research to the commandant of the USAF School of Aviation Medicine, Dr. Strughold has recently received the Air Force Exceptional Civilian Service Award.

Brig. Gen. M. Samuel White, Air Force flight surgeon and Director of medical staffing and education in the Surgeon General's office, was installed as the new president of the association.

Captain Miller To Head Pacific Directorate

All activities concerning the development and operation of the new Pacific Missile Range will be under the control of a Directorate headed by Captain Walter B. Miller, U.S.N., formerly Deputy Director of Tests at the Naval Air Missile Test Center, Point Mugu, Calif.

The range, which will be the nation's largest missile test range, will be utilized by all three services under an arrangement similar to that in effect at Cape Canaveral and the Army's White Sands Proving Grounds. Both shore-based and ship-based instrumentation will be used.

DuMont Instrumentation Controls Nuclear Plants

An instrumentation system to be used in proving nuclear reactor design, will be incorporated in training programs for personnel serving aboard the Navy's nuclear-powered submarines.

Developed by Allen B. DuMont Laboratories, the instrumentation will be used in a land-based prototype of a nuclear sub plant developed by General Electric for the AEC.

The system monitors nuclear reactions continually and indicates rate of change of neutron flux from "start up" to "full power," incorporating instantaneous shutdown when the upper safety limit is reached.

Defense To Standarize Specification Drawings

A single specification for procurement of engineering drawings to become effective within a year is the latest aim of the Defense Department. As of now, engineering drawings are prepared in accordance with about 28 different specifications.

James H. Mars, assistant to the chief engineer of the Navy's Bureau of Ordnance, is chairman of the Armed Services Ad Hoc committee. A series of meetings are being held in which

both industry and the Armed Services will participate, in an effort to get satisfactory single specifications.

One such meeting will be held at Wright-Patterson Air Base on May 27 and 28. About 25 representatives of industry will attend; including representatives of Aircraft Industries Association, American Ordnance Association, Electronics Industries Association, National Security Industrial Association and Society of Automotive Engineers.

Col. C. M. Howze, chief of the Cataloguing and Standardization Branch of AMC's Directorate of Supply, will be the host at the meeting. Members of the committee at Wright-Patterson AB include: Daniel J. Bennett and Russell Eaton of AMC; Frances D. Floto and A. G. Adman of Wright Air Development Center.

New Army Reserve Unit To Study Rocket Projects

A new and somewhat unique Army Reserve unit was formally organized at the Sacramento plants of the Aerojet-General Corp. last month.

The 6501st U.S. Army Reserve Research and Development Unit will enable reserve officers to earn credits by working on projects connected with rockets and the logistical support of rockets and missiles.

Lt. Col. C. W. Hash, senior advisor to the Army Reserve in Sacramento, reported that the rocket research and development project will help Army reservists broaden their technical knowledge of missiles, and acquire know-how that will be useful in the event of active duty.

The unit will consist primarily of men employed at Aerojet and nearby military installations.

Douglas Organizes Group To Plan Space Program

Key scientists and engineers of Douglas Aircraft Co. have been named to a special planning group to chart the Company's participation in space flight.

Reporting to A. E. Raymond, engineering vice-president and head of the company's recently-formed Engineering Council, will be M. W. Hunter, R. B. Canright and Dr. W. B. Klemperer, Missiles Engineering; P. R. Compton, Long Beach Division; Dr. E. B. Konecci, Tulsa Division; H. T. Luskin, Santa Monica Division; A. M. Mayo, El Segundo Division; and C. E. Pettingall, Testing Division.

The group will investigate basic fac-

tors in space programming and weigh merits of space flight proposals.

ASME Materials Handling Session In Cleveland

A space and atomic age session in materials-handling engineering will be held in Cleveland, June 12. The session will be on the agenda of the American Society of Mechanical Engineers meeting.

The ASME materials handling conference is being staged in connection with the National Materials Handling Show, June 9-12.

Erik Bergaust, m/r executive editor, will be chairman of the special session. Featured speakers will include: Michael Mastracci of American Machine and Foundry Co., New York, and Col. Leonard Winget, Corps of Engineers, Research Development Laboratory, Fort Belvoir, Va.

Topics discussed will include "Operations Research in Materials Handling;" "New Developments in Materials Handling;" "Design and Development of Special Equipment," and "Missile and Space Age."

Falcon Model Presented To Smithsonian Institute

A production model of the first operational air-to-air guided missile, the Hughes *Falcon*, was presented recently to the Smithsonian Institution, Washington, D.C. Senator Goldwater (R. Arizona) made the formal presentation.

The display of the *Falcon* missile, produced for the Air Force by Hughes Aircraft Company, Tucson, Arizona, will be exhibited in the National Air museum, where a permanent rockets and missiles section will be established.

IGY Rocket Probe Achieves Atmosphere Data

The National Academy of Sciences' IGY Committee has completed a successful season of rocket probings of the upper atmosphere at Fort Churchill. Manitoba, Canada, with the launching of 41 rockets since July. Firings will be resumed in mid-June with 32 more launches scheduled.

Twenty-two of 23 rockets fired this year produced desired scientific data. Rocket vehicles used and planned for probes between 46 and 160 miles out include the *Oki Phase II-Dart*, the *Nike Cajun* and *Nike-Asp*, and the *Aerobee* and *Aerobee-Hi*.

Data accumulated is expected to

give new information on the altitude of the electric currents responsible for disturbances in the earth's magnetic field during an aurora.

Information will also be acquired on the nature, extent, and location of electrons and ions at high altitudes which govern radio transmission.

Sputnik III Scheduled For May Day Celebration?

According to informed sources, the Soviet Union had tentatively scheduled the launching of *Sputnik* III for May 1, in celebration of the communist party's traditional holiday.

The satellite was to be as large as, or larger, than *Sputnik* II, and would contain instrumentation and experiments greatly superior to the first two Soviet satellites.

The most spectacular single experiment planned for *Sputnik* III is an attempt to create living matter through the action of cosmic rays on inorganic material. The experiment will utilize a mixture of ammonia, methane, steam, and carbonic acid.

It is expected that this mixture will reproduce, as closely as possible, the composition of the earth's atmosphere at the beginning of the first era. The action of cosmic radiation on this material is expected to verify or disprove Soviet and American hypotheses concerning the origin of life.

Other reports indicate that the Soviets are training another small dog, "Alpha", for flight in *Sputnik* III, and are working on a method of recovering the dog from its orbit.

A hermetically-sealed space cabin will be fitted into the main structure of the satellite, utilizing retro rockets and drag devices developed by the USSR to reduce the velocity of the cabin as it reenters the atmosphere.

After ejection of the dog's cabin from the main satellite, *Sputnik* III will continue in its orbit and may possibly use solar batteries for longer transmission-life of its equipment. Specific electronic, cosmic, X-ray and solar radiation experiments will be more refined than those incorporated in *Sputnik* II, Red advisers say.

EIA Contracting Program Will Tour the U.S.

A "Methods of Contracting" symposium, sponsored by the Electronic Industries Association, was held in Washington on April 22.

The one-day meeting, attended by nearly 80 member company representatives, was held by the Military Systems Management Committee (formerly Guided Missiles Committee), under the chairmanship of F. R. Lack, who is a vice president of Western Electric Co.

The principal speakers at the meeting were:

S. C. Donnelly, Assistant Works Manager, Western Electric Co., who discussed "Prime-Subcontracting methods of procurement on Defense contracts"; James D. McLean, President of Hoffman Laboratories, who spoke on "Group Contracting"; and W. M. McFarland, Executive vice president of Hazeline Corp., who spoke on "Leader-Follower Contracting."

The meeting evoked such interest that the committee is now considering a repeat of the program in some of the major electronic centers throughout the U.S.

Thor-Vanguard Shoot Not Classified as ICBM

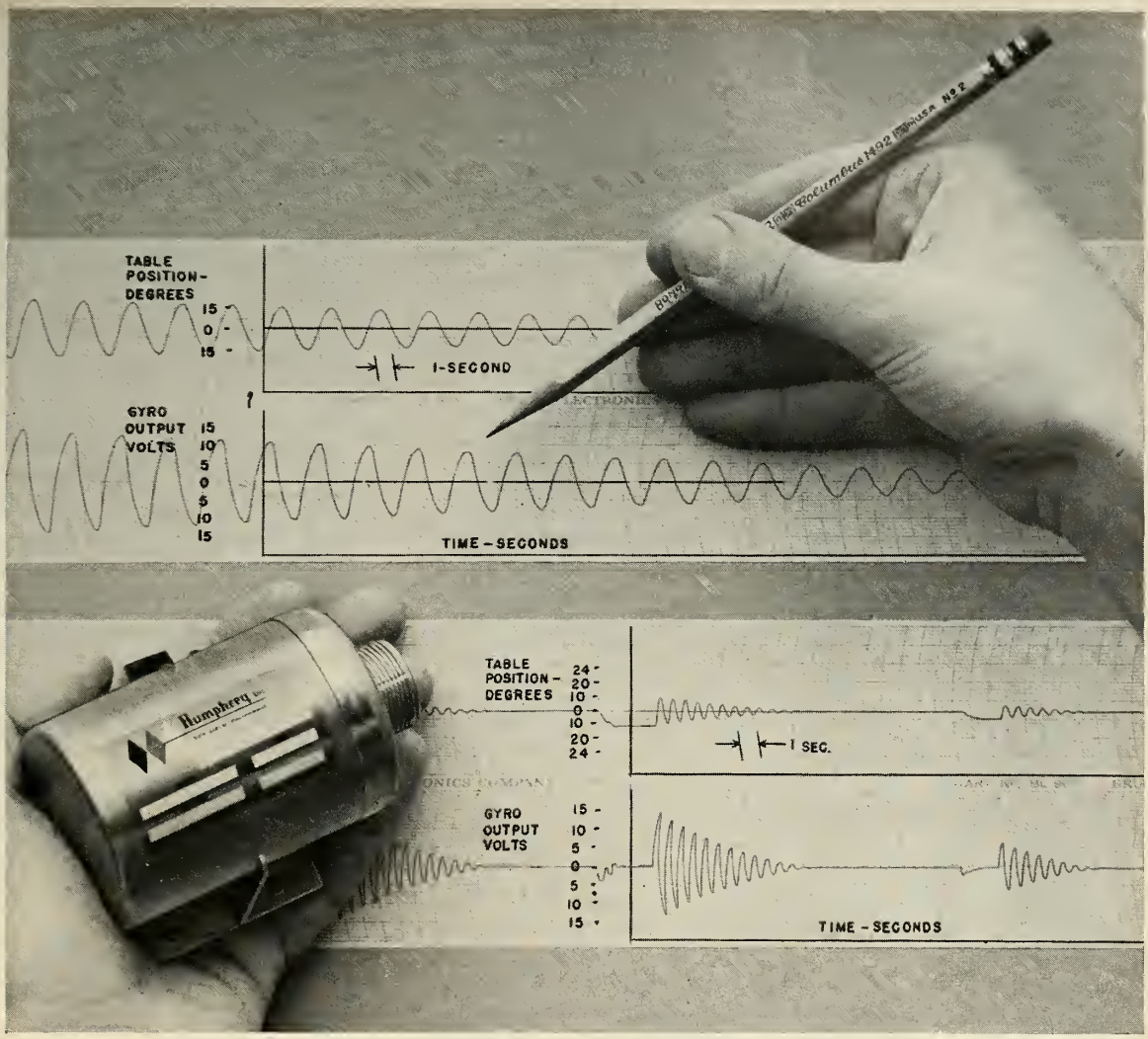
Despite repeated urging by a member of the House Committee on Astronautics and Space Exploration, Maj. Gen. Bernard A. Schriever refused to classify the April 23 *Thor-Vanguard* shoot as a successful ICBM launching. (For more information on testimony before Congress, see also p. 50 of this issue.)

The Air Force missile chief explained that to be classified as an ICBM, it would be necessary to employ "more discreet guidance" and different weight-carrying capabilities. Schriever, at the time of testimony, said it would be about three days before detailed information concerning the launching would be available.

The Air Force later called off Navy picket ships searching for the nose cone, which came down in the Atlantic about 6,000 statute miles away from Cape Canaveral, according to best military calculations.

General Schriever also commented on other subjects at the hearing, indicating that *Thor* is on schedule and that he believes the first squadron will be in operation in England by the end of the year.

He also stated that he is not strongly in favor of sending a man 150 miles up in a capsule. Schriever expects that in 15 to 20 years, man will be able to step into a rocket in New York or Washington and land in Europe 30 minutes later.



TESTS SHOW HUMPHREY RATE GYROS HAVE WIDE DYNAMIC RANGE WITH USEFUL POTENTIOMETER OUTPUT

A 150°/sec. range Humphrey gyro in tests on a torsional pendulum rate generator shows reliable output with inputs down to less than 1 degree amplitude at ⅓ cycle per second. Frictionless spring steel flexures and floating piston dry gas damper are design features that provide low threshold and practically zero hysteresis performance.

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. . . news and trends

Pershing Costs May Run $900 Million, Report Says

M/r has learned Army Ordnance's solid-propellant *Pershing* program possibly may run as high as $900 million and the timetable for production of the second generation missile is three years.

Pershing's test vehicle will have two stages; a 30-ft. length and a 24 inch diameter. Sources say the second stage, which will separate at about jet stream altitude, will have parachute recovery. A camera will be mounted in the final stage to take photographs within a four to five mile radius of the impact areas.

Such a small diameter indicates the Martin Company, prime contractor for the 500-700 mile MRBM, apparently will put design features of its pencil-shaped *Vanguard* structure to a new and improved use.

Warhead-wise, it probably will mean a payload meeting, or exceeding the Navy's 650-pound *Polaris*. The Army's 200-mile limit on allowable missile range has been relaxed, according to Army Secretary Wilber Brucker, to the extent that whatever range possible with *Pershing* can be Army's operational capability.

Martin's Orlando Division plant, the first missile industry facility under Army administration, will have complete systems responsibility for *Pershing*, although supervision will be by ABMA.

Award of the *Pershing* contract last month, worth several million dollars initially, to Martin Orlando—one of six bidding contractors—was a departure from the Army's practice of developing weapons at government arsenals rather than giving weapon system responsibility to a prime contractor. However, Martin has sales campaigned actively for more Army projects since establishing its Orlando Division, where Army's *Lacrosse*, and the *Missile Master* electronic control system are being produced.

Pershing, sources say, will be statically tested on Martin's 7,000-acre pine wood site south of Orlando. Flight tests, possibly in 24-30 months, initially will be at Cape Canaveral, Fla., about 60 miles from the Martin plant.

While no firm committment has been made on *Pershing's* two solid propellant engines, Aerojet-General Corp. and Thiokol Chemical Corp. reportedly are neck-to-neck.

Martin has a half-million square foot facility at Orlando, but with three weapon systems in production, they are feeling a space pinch. Further building expansion probably will be dictated by *Pershing*.

List Solid Booster Data for Holloman Test Track

ALAMAGORDO, N. Mex.—The Holloman track at Air Force Missile Development Center has released data on commonly used solid boosters. Although liquid-propellant systems with short burning times are available, liquids are recommended only for burning times in excess of 10 seconds and where 20 or more runs are to be made. The table presents data on solid units used at Holloman.

UNIT	THRUST (lbs.)	TIME (secs.)	LOADED WT. (lbs.)	EMPTY WT. (lbs.)
Loki	3,150	0.78	17.8	5.6
5" HVAR....	5,800	0.86	83.3	59.3
1. 8KS-7800..	7,800	1.8	118.0	48.0
2. OCS-10000	10,000	2.0	224.0	122.0
2. 2KS-11000	11,000	2.2	256.0	113.0
2. 5CS-18000	18,000	2.5	570.0	310.0
3. OKS-47000	47,000	3.0	1384.0	654.0
5. OKS-4500	4,500	5.0	236.0	111.0

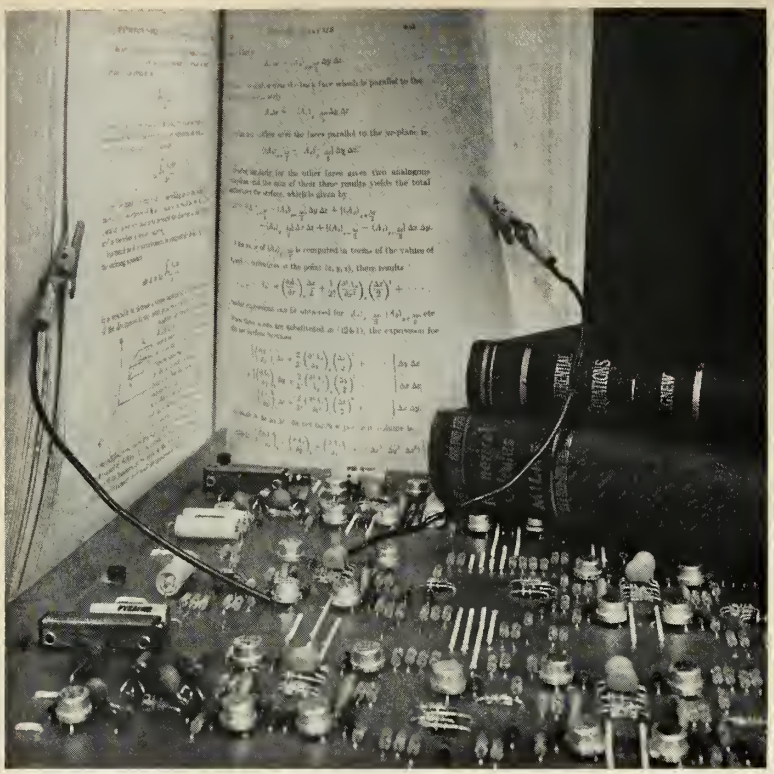
Ballistic performance of solids are usually ±10% but control of specs can bring it down to ±5%. Careful conditioning of units to temperatures prescribed by manufacturers results in predictable performance to ±3% of rated thrust or less. The liquid unit in operation at this New Mexico track has the following characteristics:

Thrust, Preset (lbs.)	35,000 to 50,000
Propellant	LOX-Alcohol
Starting Wt. (lbs.)	3,200
Propellant Wt. (lbs.)	1,400
Burning Time (secs.)	up to 4.5
Maximum Velocity (ft./sec.) ..	1,800
Maximum Payload (lb.)	1,200
Acceleration (g)	4 to 11

Cold Box for *Nike-Hercules* Makes Weather for Testing

WHITE SANDS, N.M.—A mobile weather maker—costing $80,000—is now simulating hot and cold field conditions for the *Nike-Hercules*. The portable conditioner can reach temperatures of –100°F to 200°F. The designer is Guldemann Construction & Engineering Co. of El Paso, Texas. Actual fabrication of the unit—measuring 60 feet long, 14 feet high and 15 feet wide—was by another El Paso firm, P&R Truck Equipment Co.

Built in two sections, the box can completely cover the *Nike* while it is on its field launcher just prior to firing. It takes about two minutes to pull the two halves apart and fire.



Packard-Bell

m/r staff report on markets:

Most Missile Money Goes to Subsystems

MONEY FOR MISSILES is divided between the following kinds of contractors: prime systems, subsystems, components and vendors.

By far the largest of these breakdowns is subsystems; next, probably, components. Not only do Government contractors buy subsystems direct, but between 50 and 80% of all money placed as prime systems contracts funnels right through the prime contractor to subsystems and components equipment suppliers.

Though no precise over-all figures are available, this probably means that of the $3 billion to be spent on missiles this year, some $2 billion will be spent on subsystems and components. This total should hit $2.5 billion out of approximately $3.5 billion in Fiscal Year 1959, and over $4 billion out of about $6 billion in 1960. Missile research and development is something else again and is carried in separate fiscal accounts.

Beyond 1960, the sky (literally) is the limit, and it's anybody's guess as to what that limit is. Least of all do top Defense Department budget planners know how big the rockets, missiles and space flight tab will be in 1961 and after. Nor will they, until the present period of elementary soul-searching and decision is completed—probably along about next fall, in time for working up the fiscal 1960 budget requests.

All of these figures are applicable only to missile and immediately-related procurement. They include *Polaris,* but not the launching submarines. They include *Bomarc* plus launchers, etc., but not the actual construction of the bases—a considerable sum in itself.

They do not include that portion of research and development that goes for missiles—perhaps half the $2 billion slated for fiscal year 1959.

Nor do the budget figures stated earlier include all of the ground-based electronics required for missiles and missile support. The Pentagon does not give out missile share of these figures. But it's a safe bet that a healthy portion of the $864 million allotted to "electronics and communications" in 1959 will have to do with missile subsystems. Add in these items and you can figure on another $1-to-$2 billion in missile-related procurement.

• **Place in the industry**—Subsystems and components cover that mammoth area of the missile market between the prime systems contractor and the vendor—without them the former would not have a product, and the latter would not have much of a market.

Most subsystem contracts are placed by prime systems contractors, though when a missile reaches the production stage, the government also becomes an important customer. In the case of the Air Force's big ballistic missiles, all subsystems contracts, even at the research and development stage, were placed as prime contracts by government procurement.

Normally, however, the company with systems responsibility places all contracts for the completed missile system; at least this is true up to the point where the "bird" goes into volume production. At that point the government may or may not take over responsibility for placing subsystems contracts on a "negotiated bid" basis. The practice seems to vary arbitrarily.

• **Definitions**—A subsystem is a major working part of the missile; a component is a working part of that subsystem. Thus the component—a complete-but-empty solid rocket motor casing, for instance—becomes a subsystem once it's loaded with propellant and ready to be integrated into the missile. In another case, an inertial reference platform is a component of an inertial guidance subsystem.

By one definition (and these vary both in industry and government) the typical subsystems include:

Payload (warhead), guidance, control, auxiliary power unit, propulsion, missile body, ground support, ground handling gear and launching equipment.

In turn, these break down into components like this:

PAYLOAD is made up of container, explosive (if that's its mission), and fusing mechanism.

GUIDANCE consists of a position locator (radar, radio, infrared, sound, inertial reference platform, celestial

triangulator, etc.), computer (which may be missile-borne, ground based or both) and instructor circuits.

CONTROL has two major components: transmission (hydraulic, electrical or mechanical) and controller, such as movable aerodynamic fins-vanes placed so as to deflect the rocket exhaust gases, a gimballing system on a liquid propellant engine, special auxiliary jets powered by steam (H_2O_2), or rocket exhaust to control roll, pitch and yaw.

In addition, there are thrust controllers, engine cut-offs, stage separators, and flow-metering circuits.

The auxiliary power unit supplies power for guidance and control. Its components break down into a hydrogen peroxide generator; a small rocket motor or a bleed-off system from the main rocket exhaust; turbine; alternator; and hydraulic pump. Or, if it's battery powered, batteries replace the high velocity gas source and turbine assembly.

Except for air-breathing missiles, which use ramjets or conventional turbojets, propulsion divides between liquid and solid propellant rocket motors. Components for solid rockets consist of casing, liner, resonance rods (if any), igniter and of course the charge itself—a polymer-bound mixture of oxidizer and fuel. Liquid engines are more complex. They include: fuel and oxidizer tanks, pumps, valves, injection head, combustion chamber, and nozzle assembly.

• **Airframe and support**—The airframe may be ribbed, skinned and riveted (as with aircraft), but more often it's machined and welded, either of steel or aluminum and—rarely—of plastic.

Airframe, in this definition, also includes the nose cone, which may be machined from a heavy forging and coated with heat resistant material to enable it to withstand the high heating rates of reentry into the earth's atmosphere; or it may have to be transparent to infrared and radar and thus be of plastic or glass.

GROUND SUPPORT equipment includes such components as: Liquid oxygen generators, ground-based computers, check-out gear ("go, no-go boxes"), ground-based computers, radar, telemetry receivers, fuel trucks, pumps, fire fighting equipment, protective clothing, cherry pickers, pressurized nitrogen and helium transporters, electric blankets (to keep solid propellant rockets warm in winter), and portable electric generators.

GROUND HANDLING equipment is the gear that actually handles and moves a missile about. This may be a gantry crane, a dolly, a tractor-trailer combination, various special fittings, etc.

LAUNCHING EQUIPMENT is the launcher that holds and positions the missile for firing. Its components would probably include a hydraulic system, power supply, launcher and blast deflector equipment.

Generally speaking, ground support, ground handling and launching are lumped into a single generalized equipment category.

In addition to these various individual items of hardware, with bigger missiles such as ICBMs, and with anti-aircraft missiles like *Nike* and *Bomarc*, there is a considerable amount of site construction—calling for such things as reinforced concrete, roads, underground storage tanks, buildings, and hangars.

And with each individual missile system, there are always a few unique problems, depending on whether the bird is big or small; whether it's air-launched, ground-launched or ship-launched; whether it's a fixed base item or is mobile; whether it needs to be air transportable or air dropped.

Take *Polaris*, for example. With any long range ballistic missile, the precise location of launch, relative to target, must be known in order to feed in proper guidance instructions. *Polaris* will be launched from a submarine. So in addition to everything else, every *Polaris*-launching submarine will have to be equipped with a highly complex and costly system known as SINS—Shipboard Inertial Navigation System—in order to fix its position.

It's tough to separate markets. No one in the Army, Navy, Air Force, Advanced Research Projects Agency or the Department of Defense has yet been able to "break down" missiles—as to industrial requirements per program, flow and distribution of money to and through industry, their total impact on the economy. In other words, there is no easy way to determine who's got the money, which subsystems get the most money, just where the most lucrative markets are.

• **Ways to figure**—However, there are enough individual examples floating around to enable an enterprising salesman to draw his own conclusions.

No two missiles are alike, but a very rough break-down of how the missile system money is distributed to the various subsystems goes like this:

Missile-borne electronics and guidance, 20%; control, 5%; payload, 15%; propulsion, 10%; ground support, 15%; ground handling, 10%; launching, 10%; airframe, 15%. In the larger missiles (to which these figures apply) the cost of an auxiliary power unit in production runs less than 1%.

From another viewpoint, recently released figures for a 10-bird operational *Atlas* ICBM base, state that the 10 missiles on site will represent less than 20% of the total cost. Almost 40% will be in ground-handling, support and launching equipment, 10% in spare parts and 30% in what the Pentagon calls "technical facilities."

Actually, if you add up all the electrical-electronic gear in a missile system you'll often come up with a value of over 50% of the whole system.

Take *Thor:* this bird now costs about $1 million. Its missile-borne guidance accounts for about $250,000 of that—though hopes are to get the price tags down to $750,000 and $190,000 respectively. Present cost of guidance for *Jupiter* is also $250,000. A launcher for a *Bomarc* costs between $45,000 and $65,000, depending on who is bidding.

An empty *Nike* booster case costs something under $1,500. A machined magnesium housing for an autopilot electronics package may run $200-to-$300. A wave-guide for checkout balance system may run $35; a thrust sustainer cone, $3,900. A small solid propellant motor, such as *Recruit* can be had, off-the-shelf, for under $1,500. Its bigger brothers, such as *Polaris'* main stage propulsion unit, will run to many thousands of dollars.

• **Who buys**—As to who the customers are—the answer can be almost anybody.

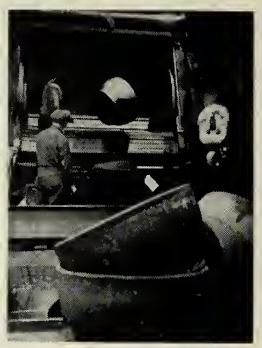
All told, there are two-to-three dozen prime systems contractors scattered all over the country.

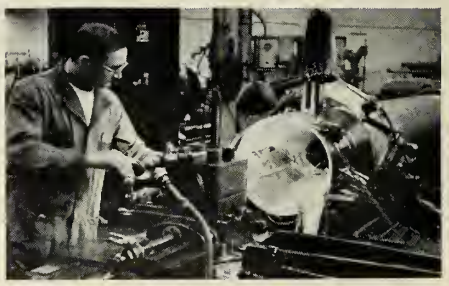
According to Courtland S. Gross, President of Lockheed Aircraft Corp., of 43 missiles of all types, West Coast companies are involved in 25 and have prime contracts on 14. Convair-Astronautics spends up to 70% of its missile money outside of the division. One estimate is that Convair-Astronautics will spend $92.3-million this way in 1958. Boeing also subcontracts out 70% on the *Bomarc*, including all ground support equipment. Raytheon Manufacturing Co. subcontracts all ground support and propulsion on the *Hawk*.

Ford Instrument Co., a division of Sperry-Rand, subcontracts 75% of its work on *Jupiter* guidance outside of the division and 35% outside of the company entirely. AC Sparkplug division of General Motors figures on spending 50% outside of its own plant in its work on *Thor* guidance.

This, in brief, is the missile subsystem and component market.

It is big and getting bigger.





Photography by Seabrook Hull

COMPONENTS in production

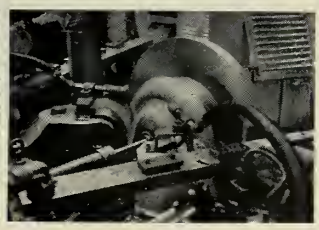
IT TAKES A LOT TO MAKE A MISSILE—a lot of man-hours, facilities, steps, skills—and lots of money. Bits, parts and pieces are made from basic stock; these are put together and become components; components, assembled, become subsystems; and subsystems become weapons systems. On these two pages are components in the making.

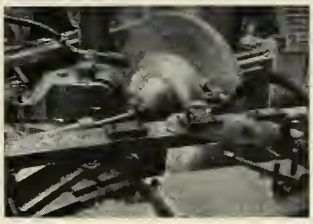
The totem-pole series of pictures to the immediate right begins with a missile piece being forged at Ladish Company. Moving down the column, the aft closure forging of a *Nike-Hercules* sustainer comes out after shot-cleaning—ready for rough machining. Next, a machinist at the Ingersoll-Kalamazoo division of Borg-Warner Corp. does final truing up of a *Nike* booster casing after heat treating. Then, a Government inspector uses special equipment to check dimensions and tolerances. And finally, the completed *Nike* sustainer is carefully transported to the paint shop.

The unusual pattern in the picture to the top left of this page might be entitled: "So you think you know rockets!" A few readers will recognize these structures as resonance rods to stabilize the burning in a solid motor.

For another pattern in missilery, note that photograph to the lower right of the page opposite. This sparkling array of *Nike* sustainer casings is dramatic proof that today the missile is indeed a production item.

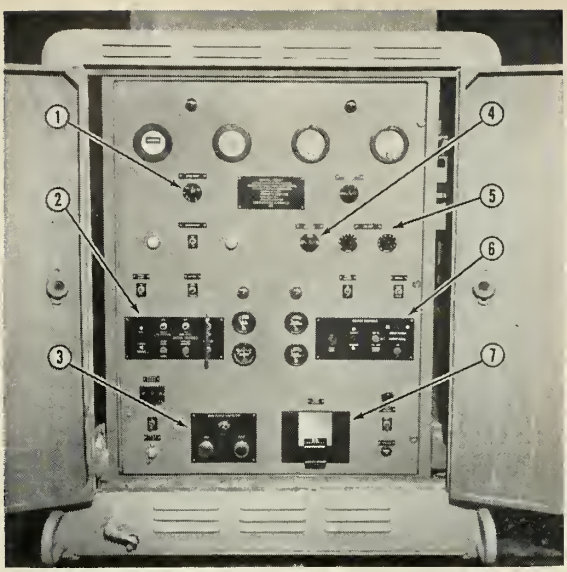
Just as the research and development of rockets and missiles brought forth whole new sciences and technologies, so does their entry into production bring changes and improvements to the assembly line. Here, through a marriage between hydrospinning and precision machining, time and dollars are cut from the cost of a nose section for an IRBM. This production technique holds great promise for the manufacture of even larger one-piece missile sections. This technique is applicable to hemispherical shapes, nose cones, nozzles, and even large rocket casings. Virtually any metal from aluminum through the range of the high temperature alloys is susceptible to this approach. These pictures were taken at Diversey Engineering Company who, along with Borg-Warner and General Electric's Rocket Engine Section, is pioneering hydrospinning.





Closer tolerances in the production of large metal sections are called for in rocketry than ever before has been required of a mass production industry.

To the left, a final check of finish and dimensional tolerance is made before shipment of the IRBM nose section. The picture at lower left shows another vital step in the production of a large solid propellant motor. Here, the core mold that will define the rocket's burning area is being machined on a Monarch air gauge tracer lathe. This is a touchy operation: the mold is machined from solid stock of the highest quality. If at any point too much material is taken off, the piece must be discarded. Such requirements are commonplace on missile assembly lines. Rejections are few—a real credit to American industry.



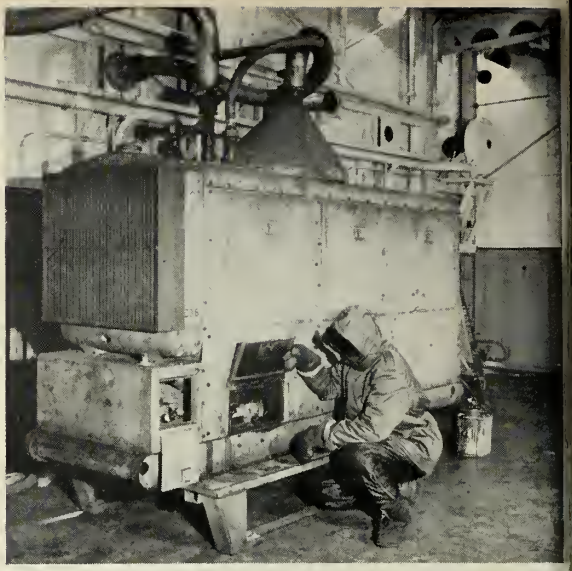


FIG. 1 AND 2—End view of diesel-powered electric set control panel showing: 1) Speed droop control 2) Engine controls 3) Main power contactor 4) Voltage reference 5) Line droop compensation 6) Heater controls 7) Main power circuit breaker (left) An electric set is shown (right) undergoing testing in a "cold room" facility.

Diesel Units Power Ground Support

by J. H. Ashton*

IT HAS BEEN SAID that more money is spent on ground support equipment than on missiles themselves. This may be an exaggeration, but it does point up the growing importance of ground support equipment in the military weapons system.

The switch to jet aircraft, with their electronic navigation and fire control systems, required ground power units to be changed from low voltage dc to 400-cycle ac. This reduced the size and weight of airborne gear and eliminated low voltage power line loss. The switch to missiles, demanding high accuracy, increased operating speeds and extended range of operation have expanded these requirements. Quality power is directly reflected in higher quality components requirements for using independent ground power units.

There are three basic reasons for using independent ground power units. They must be able to operate independently of utility power sources, since utility power stations, substations and transmission lines are extremely vulnerable to sabotage.

The units must be mobile to permit missile sites to be moved swiftly from one location to another for evasive actions.

There is also the need for more precise control than is available from utility power sources.

A diesel-driven electric unit that provides power at calibration and during firing standby for the *Snark* missile is shown at upper right. At the time of launching, the diesel electric unit is operated in parallel with the missile's internal power supply. Accuracy of the missile will depend upon the accuracy of calibration and the calibrating power unit. The calibration margin of error becomes more critical as the range of the missile and speed of operation is increased.

• **Unit Power Requirements**—Procurement specifications for the diesel-powered electric set used with the *Snark* missile require that the unit be capable of:

1) Rating of 60 KVA at 0.8 power factor (48 KW—capability of 60 KW), 120-208 volt, 3-phrase, 4-wire, 400-cycle. Speed of operation 1714 rpm, approximate weight 6000 lbs. without undercarriage.

2) Amplitudes of all harmonics (peak values) not to exceed 2 per cent of the fundamental amplitude at no load, half load and full load.

3) Voltage to recover and remain within one per cent of rated value in 0.15 seconds or less under full load application or rejection. A voltage transient not to exceed a band between 108-121 volt range for more than 1.25 milli-seconds with the nominal voltage set at 115 volts for a 25 per cent load variation. Under full load transients, the frequency must stabilize within 1.5 seconds, with the speed not exceeding a plus or minus three per cent of rated speed.

4) Voltage modulation must not exceed one per cent from zero to full load with per cent of modulation defined:

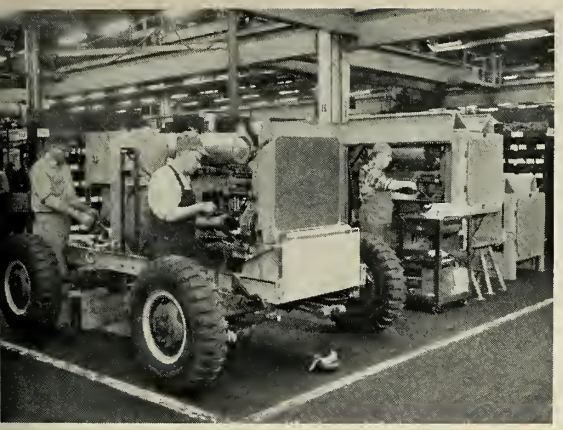
$$\frac{\text{Emax.} - \text{Emin.}}{\text{Emax.} + \text{Emin.}} \times 100$$

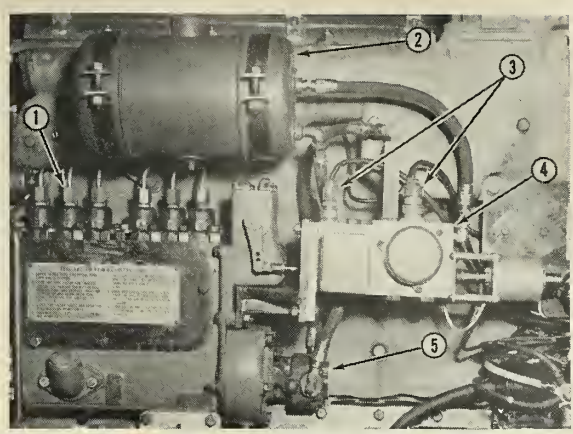
5) Output frequency to be within a band of ± 1/3 of one per cent of all stead-state load conditions from zero to full load.

6) Unit to be winterized for starting and operation at –65°F.

7) Must have local and remote control operation of frequency and voltage.

Manager, Engineering Engine Division, Caterpillar Tractor Co.





IG. 3 AND 4—The final assembly line in the Caterpillar electric set manufacturing plant (left). Wheel and skid mounted 400-ycle units are produced on parallel lines. Closeup of fuel system (right) 1) Fuel injection pump 2) Hydraulic fluid reservoir) Hydraulic servo and governor electrical connections 4) Hydraulic servo 5) Hydraulic pump

8) Provide line group automatic ompensation for any combination of esistance and reaction drop up to ten er cent.

9) Provide voltage sensing at either ocal or remote terminals.

10) Electric set to be skid-mounted ith provisions for trailer under-car-iage and running lights.

11) Unit to be designed for all nvironmental conditions including igh and low temperature, humidity, ltitude, salt spray, fungus, rain, sand nd radio interference.

•**Diesel Operation**—The diesel en-ine power package can meet most issile requirements, and is constantly eing improved. An example is the old-room tests performed in a con-nuing effort to improve the operating mitations of the engine (Fig. 2).

In a diesel engine, fuel metered into ie combustion chambers provides fast esponse after a load change is in-icated by the governor. Fig. 5 shows ie operation of the fuel injection quipment. A close-up of the mounting f the hydraulic components of the overnor is shown in Fig. 4. Interior nd exterior views of the electrical ontrol panel are detailed in Fig. 1.

In addition to the requirement for ortable electric sets, there is also a equirement for stationary power units. hese units are used in fixed missile stallations and for support of dc-elopment programs, such as com-unication requirements and down-nge missile tracking stations.

•**Production Development**—Diesel ectric units are procured late in the evelopment period of the missile sys-m, since most of the individual ystem requirements are not known ntil their development is complete. urthermore, it is impossible to deter-mine early in the program the quantity and quality of power that will be required. Thus the manufacturer must guarantee performance with an extremely short lead time prior to actual production.

A number of electric sets, in various configurations, are currently being supplied to the missile support market. Increased activity in the development of both offensive and defensive weapons systems will greatly expand the market for diesel electric sets and other diesel powered support equipment. Each missile system will undoubtedly have individual requirements which will prevent any great degree of standardization.

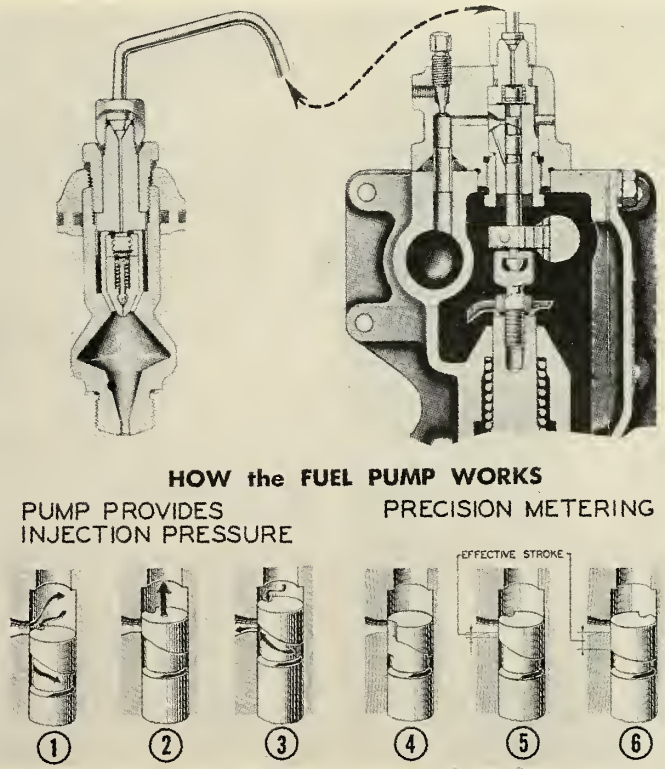
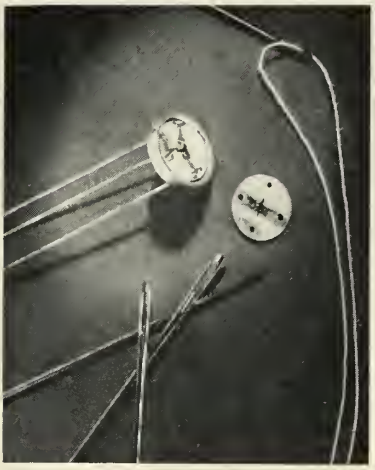


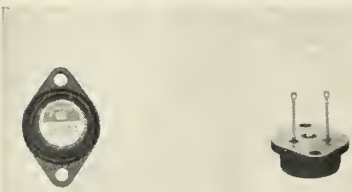
FIG. 5—Schematic of fuel pump operation. 1) Pump fills 2) Injection begins 3) Injection ends 4) Shut off 5) Idling 6) Full load

An m/r Missile Component and Products Survey:

Tiny, Rugged—and Vital to Missiles

by Frank McGuire





One highlight of this year's IRE show was the variety of new ideas in the transistor field. Transistors rugged enough to be shot from a 12-guage shotgun (upper left) were displayed by the General Electric Company. The extreme ruggedness achieved with these units stems from a newly-developed mounting of a germanium or silicon bar. Instead of suspending the germanium or silicon between upright posts in the conventional manner, GE mounts the semiconductor on a flat, circular, ceramic wafer. The wafer rests solidly on the base of the transistor housing.

Delco division of General Motors showed a new high-power, high-frequency transistor (center left) featuring a maximum collector voltage of 80 volts, low leakage current, and high temperature characteristics. At 25°C, the collector cutoff current for 60 volts is only 2 ma maximum, and at the important operating point of Vc= 2 volts, the collector cutoff current is 50 microamperes maximum.

Two new developments in all-glass housings were shown:

General Electric displayed a package claimed to be the first in meeting the TO-9 outline dimension standard for low power signal transistors recommended by the industry's Joint Electron Tube Engineering Council (bottom left).

Corning glass works introduced a two-piece transistor case (bottom center), with case pieces hermetically sealed at 1000C, while temperature near the semiconductor element are kept in the region of 150C. Current production is limited to the 200 mil lead circle type, but Corning claims that other sizes will be available in the future.

Another product displayed by Corning was a fused silica crucible for melting silicon, germanium and other semi-conductors where extremely careful control of purity is required. The new crucibles (bottom right) are made by automatic production methods from fused silica; pure silica glass with impurities measured in parts per million or less

n silicon crystal growing, this glass s used in temperatures near 1450°C. The crucibles are being made in sizes ıp to two and one-half inches diam-ter and three inches long.

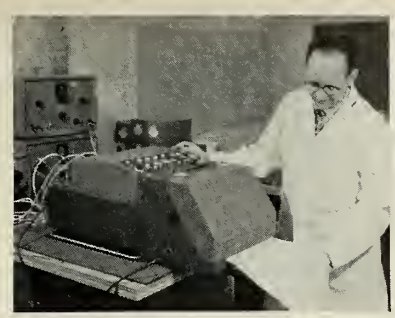
Consolidated Electrodynamics has leveloped a new instrument in the scillographic field, the Datarite (top eft), a combined magazine-and-rocessor which allows a test en-ineer to view test data a split sec-nd after it has been produced. By neans of a revolutionary processing echnique, the new unit provides de-eloped and dried photographic rec-rds as fast as the recording oscillo-graph registers the data.

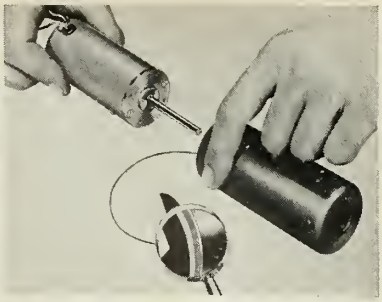
Two models of the Datarite fit Consolidated's type 5-114 and 5-119 ecording oscillographs without modi-ication of any kind. The flash-pro-eeded record emerges from Datarite mmediately, and the traces are in-tantly visible as the record leaves he slot. After fixing, quality is equal o conventionally-processed records. However, fixing is unnecessary as the ecord will become stable in a few lays without further processing.

Another new product, a highly nique 3-layer motor shield (top ight) to attenuate magnetic and elec-rostatic noise, was displayed by the Magnetic Shield division of Perfec-ion Mica Company. The shield at-enuates both high and low frequen-ies at high and low intensities, per-nitting miniaturization of servo, syn-hro and other small motor systems y confining the motors radiated oise.

Avco's Research and Advanced Development Division has now made t possible to transmit information at ither 1/50th or 1/20th of its record-ng time. This two-unit precision ape-recording communication system s called the Avcom Compressor-Ex-pander, model CEM-50-1 (second rom top right).

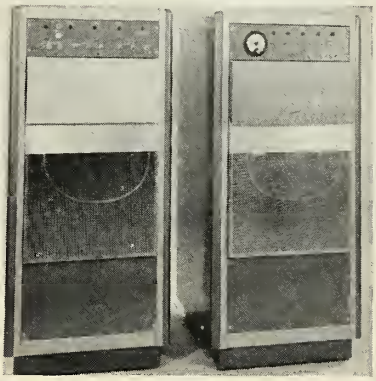
The unit allows high-speed trans-er of serialized digital information at 200 words per minute (20:1 com-pression ratio) occupying a band-width from 300 to 3000 cps. At 50:1 ompression, output of 3000 words per minute is achieved on a trans-





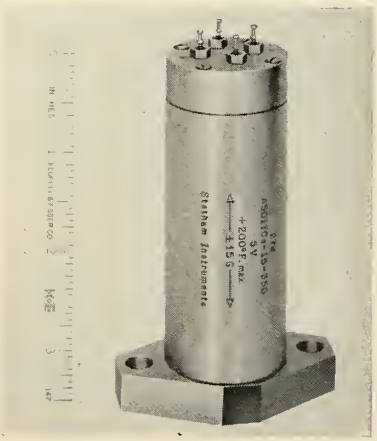
mission band from 750 to 7500 cps. These high-speed digital signals are recorded for direct operation of a standard teleprinter or tape puncher at a low-speed playout of 60 words per minute.

Corning Glass announced that it was now producing CY-type fixed glass capacitors with a full rating at 125 degrees C (third from top right). Meeting all MIL-C-11272A requirements, these capacitors are available with voltage ratings of 300V and 500V DC. Volume of the capacitors range from 0.005 cubic inches for the CY10 to 0.080 cubic inches for the CY30. For applications where extreme miniaturization is needed, capacitors with one-tenth the volume of standard CY types are attainable.



Statham Instruments Inc., announced the development of a new concept in the design of unbonded strain gage accelerometers. The use of gas damping, incorporated in the Model A501 accelerometer (bottom right), permits the operation of the device over a wide temperature range without the addition of a temperature jacket.

At temperature extremes, such as −65 to +200 degrees F, the useful frequency band of the A501 is approximately the same as that for a conventional accelerometer at room temperature. The new unit is offered in ranges from plus or minus 5 to 50 g's.



Other new products displayed by manufacturers include products shown on this page and on following pages of the New Products section. The theme of this issue is Components and Sub-systems.

This issue of m/r emphasizes the importance and variety of products which make up a missile and its associated equipment. There has been no attempt to make this report all-inclusive, in view of the rapid growth and diversity of the American missile industry. Because electronics and electrical equipment comprise the greatest portion of any missile system, these products are featured in this survey.

Electrical and Electronic

Waveguide Terminators Have Variable Adjustment

Polytechnic Research and Development Co., Inc. has developed a series of sliding waveguide terminations with frequency ranges from 2.6-3.95 kmc/s to 26.5 40 kmc/s, and a maximum vswr of 1.01.

These units consist of a tapered waveguide section in which is mounted a sliding low-reflection load attached to a plunger. The plunger is moved in and out of the waveguide section by means of a knob at the end of the guide. In this manner, the load position is variable through at least ½ wavelength at the lowest waveguide frequency.

This variable adjustment offers a distinct advantage in that it allows phase reversal of the residual reflection, so that this reflection can be separated from the other small reflections in the waveguide system. A locking screw allows the load to be fixed in any desired position.

In some types the load consists of a Synthane strip, while other types use a metallic film evaporated onto a Fiberglas base.

Circle No. 256 on Subscriber Service Cord.

Two-Station Thermocouple Gauge Available

A two-station thermocouple vacuum gauge is available from the Rochester Division of Consolidated Electrodynamics Corp. The gauge, designated GTC-100, measures the total pressure in a vacuum system on a single scale. The non-linear scale is marked from 0 to 1000 microns Hg, with 5 microns the lowest indicated division.

The GTC-100 can be calibrated without the use of a reference gauge. It can also be used as a moderately sensitive leak detector throughout its range from 1 to 1000 microns. The TG-77 sensing tube cannot be harmed by exposure to atmosphere. Zero drift has been reduced by the use of lower heater current to decrease the rate of thermal decomposition of organic vapors within the tube.

The GTC-100 gauge, obtainable with one or two sensing tubes for use as a one or two station gauge, can be used with an accessory panel mounting kit. The gauge is 4⅞" high, 6½" wide, 3¾" deep and weighs 4½ lbs. Printed circuitry has been used to give a smaller more compact package than previous thermocouple models. It will operate from either a 115 or 230-volt power supply.

Circle No. 252 on Subscriber Service Cord.

Waterproof Toggle Switch Has Simplified Mechanism

A waterproof switch has been developed by Control Products, Inc. This switch has a "stay-on, stay-off" feature similar to a toggle switch, without the conventional toggle switch mechanism.

The switch is completely protected against water and dust by being enclosed in a silicone boot that is permanently bonded to the silicone leads. It can be furnished in various lead lengths for other types of applications where there are severe water, steam, humidity, or chemical solution conditions.

Electrical rating is 15 amperes resistive at 115 vac with an expected life of at least 25,000 cycles.

Circle No. 239 on Subscriber Service Card.

Limit Switch Handles Extra-Heavy Loads

Two new small-size, two-circuit limit switches said to handle load capacities usually assigned to much larger limit switches have been announced by MICRO SWITCH, Division of Minneapolis-Honeywell Regulator Co.

One switch (designated ILSIO) has a rod actuator and is field adjustable through 360°, locking positively in any position. It can also be adjusted to operate in either or both directions. The head assembly can be positioned in any of four directions. This switch can be used in applications requiring low force and special lever forms.

The second switch (designated 8LS1) has a flexible coil-spring actuator that permits operation from any direction except direct pull. Easily operated by large, irregularly-shaped objects, this type is well suited to conveyor and counting applications.

On both switches, complete sealing protects all moving parts from dust and moisture. The replaceable basic switches are rated at 10 amperes, 120, 240, or 480 vac; ½ H.P., 120 vac; 1 H.P., 240 vac; 0.8 ampere, 115 vdc; 0.4 ampere, 230 vdc; 0.1 ampere, 550 vdc; pilot duty rating, 600 vac max.

Circle No. 231 on Subscriber Service Cord.

Solenoid Eliminates Mechanical Linkage

The Leetronics Co. has announced the development of a rotary solenoid embodying a new concept in solenoid design and providing true rotary motion from an ac or dc input without utilizing linkage.

A feature of the design is that the output torque and angle of rotation are easily selected and adjusted. They are changed by shifting two stops that limit rotor travel. These stops allow selection of any portion of the overall "Motoroid" torque curve and rotation that suits a design.

The Motoroid 100 Series Model is the first of a complete line. It is a medium torque model that provides outputs of up to 4 inch pounds.

The units are available in closed or open-frame type and in continuous or intermittent duty models with either left or right hand rotation standard. They have an operating temperature range of −65° to +300°F (special models up to 500°F).

Standard operating voltage is 110 V, 60 cycles ac. Other voltages and dc are available on special orders. The standard angle of rotation is 60°. Longer travels can be designed upon request.

Circle No. 234 on Subscriber Service Cord.

Decade Counter Has One Microsecond Reset

Burroughs Electronic Tube Division has introduced a new megacycle decade counter with Nixie numerical readout tube. This is claimed to be the only decade counter with provision for resetting from new position to zero in less than one microsecond.

Designed as a companion unit to the decade counters types 101 and 102, whose counting rate is 10 kc and 100 kc respectively, this plug-in unit can achieve the highest speed counting

and resetting, while still making all 10 outputs available for print-out or other general purpose applications. The power requirements are 300 v—30 ma dc and 6.3 v—0.9 a ac. The unit features high reliability through the use of the beam switching tube. The Nixie indicator provides precise in-line figures visible at 30 to 40 feet.

Circle No. 243 on Subscriber Servce Cord.

Event Recorder Features One Hundred Channels

Brush Instruments is producing a 100-channel event recorder which minimizes the amount of time, space and equipment needed to perform complex checkouts on critical systems and accompanying processes.

The instrument permits recording of 100 channels of sequential or operational information simultaneously—indicating any number of events pertaining to electrical or physical phenomena data.

The event recorder, Brush Model RE 3610 00, records static and dynamic data on a moving chart 12" wide and 500' long. A record of events, their duration and their time relationship to each other, appears on the chart less than one millisecond after the electrical current is switched through the stylus. The electric writing method provides reliable, dry and permanent charts.

Rapid response of the Event Recorder permits up to 500 signal changes per second. Instantaneous electric selection of eight standard chart speeds with on-site or remote operation, and a chart speed accuracy within one-fourth of one per cent of established speed at constant line frequency are among the instrument's features.

The device is designed for compliance with military specifications and may be mounted in any standard 19" rack, table console or mobile chart. Net weight of the event recorder is 60 lbs.

Circle No. 232 on Subscriber Service Card.

Spectrometer Features Automatic Readout System

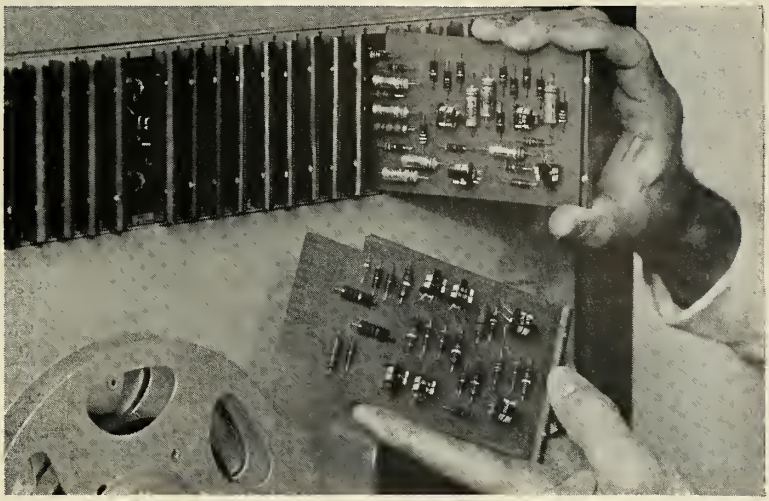
A Direct Reading Spectrometer with a completely automatic glow tube readout system has been developed by Baird-Atomic, Inc. A highly accurate analytical system to be used in conjunction with automatic data processing equipment, the B-A Direct Reader is equipped with an automatic glow tube readout system. This is the first unit of its kind to present information capable of being fed directly into electronic computers.

This auxiliary equipment permits the reader to perform 1080 determinations with complete data processing in about two hours. Prior to the automatic unit, 180 determinations with manual data transfer would require many additional hours.

The B-A Automatic Direct Reader provides simultaneous measurement of 18 of the 36 elements which the instrument is capable of measuring. The spectural intensities of these elements are measured by photomultiplier tubes positioned behind exit slits at selected wavelengths.

The output voltage of each tube is proportional to the amount of the element contained in the sample being analyzed. The voltage is interpolated by an electronic glow tube counting system into digital values, which can be handled by the punching mechanism of the IBM system and automatically processed.

Circle No. 241 on Subscriber Service Cord.



Read/Write Amplifiers Provide Versatility

Decisional Control Associates' all-transistor read/write amplifiers are claimed to provide the system designer with a complete set of building blocks for digital magnetic tape applications. The circuits are easily incorporated into any type of digital system.

Voltage levels are compatible with either transistor or vacuum-tube systems of logic. The write amplifier uses logical combinations of two input voltages to provide both return-to-zero (RZ) and non-return-to-zero (NRZ) modes of recording.

Pulse response at the two inputs is matched to assure uniform reproduction regardless of tape saturation direction or mode of recording. The basis read circuit is a linear amplifier with a voltage gain of approximately 2500.

Liberal feedback is used to preserve pulse waveform and the frequency pass band is carefully shaped to provide maximum noise rejection. A variety of transitional output circuits is available to supplement the basic read amplifier.

Modular design adapts the new circuits to use in systems of any number of channels. Each amplifier is packaged on an etched circuit plug-in card 3¼ inches by 5½ inches. A typical read/write system for eight channels, consisting of write amplifiers, read amplifiers and transitional output circuits, is contained in a single module occupying 3½ inches of panel space.

Transistors as active elements and operating margins consistent with good digital practice are claimed to result in circuits of outstanding reliability, even at high digit transfer rates.

Circle No. 237 on Subscriber Service Card.

Thirteen Ultrasonic Systems Introduced

High capacity, production-size ultrasonic cleaners, metal-finishing and chemical process machines have been introduced by the Narda Ultrasonics Corp.

The series 600 line comprises

thirteen different ultrasonic systems made up of various combinations of the SonBlaster generator and SonBlaster Ultrasonic Transducer Models NT-601 to NT-609.

The stainless steel transducerized tanks in this series range from ½ gallon to one gallon capacity with single or double tank compartments. Some feature inlet and outlet taps for hook-up with external recirculating systems; others feature self-contained recirculating pumps, filters and temperature controls.

Submersible models NT-604 and NT-605 are hermetically sealed in leakproof heliarc-welded stainless steel cases for use in installed solvent degreasing tanks, process tanks, metal-finishing, metal washing, and heavy-duty cleaning tanks of varying sizes or volumes.

Circle No. 230 on Subscriber Service Card.

AC Summing Amplifier Weighs 12 Ounces

An ac input-output summing amplifier designed for 400-cycle operation has been made available by Waldorf Instrument Co. Weighing only 12 ounces, and measuring approximately 2½" x 1½" x 2½", the unit has an all-transistorized construction offering low power consumption (50 ma drain at 45 v) and high resistance to shock and vibration.

The Summing Amplifier, W1806, may be specified with 7 or 9 pin-connectors or for connection in printed circuits. With a phase shift of less than 1° 20 cps to 1 kc, the unit has a signal frequency of 20 cps to 2 kc (within 1 db at 250 mw output), an input impedance of 3000 ohms and a 10 ohm output impedance.

Circle No. 229 on Subscriber Service Card.

Temperature Transducer Has 0.1°F Accuracy

A sensitive, highly accurate temperature transducer with fast response is being produced by Astra Technical Instrument Corp. The instrument is designed for measuring static and flow temperatures of liquid gases used in rocket motors.

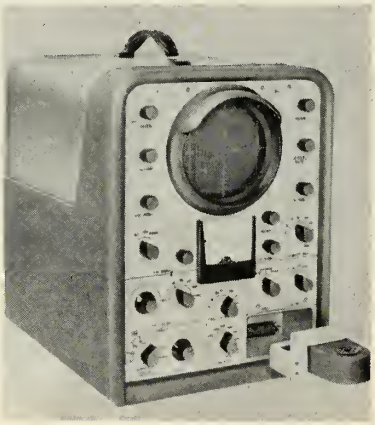
An exposed element in the unit provides a response as fast as 10 milliseconds. Using an amplifier supplied by the manufacturer, a response of one millisecond is possible. Accuracy is better than 0.1°F., depending on the ability of the readout equipment, and resolution of 0.1°F. is obtainable. Using the matching amplifier, an output of ±5vdc per 100°F. can be provided, with a maximum output of ±20 vdc available.

Maximum operating current: 5 milliamperes. Operating range:–450°F. to 2000°F. in eight increments, with +3500°F. available as special.

A probe-type instrument, it measures temperatures of air, water, ethyl alcohol, liquid nitrogen, liquid oxygen, gaseous nitrogen, lubricating and hydraulic oil, and other fluids. Unit withstands acceleration to ±25 g at 0 to 200 cps.

Circle No. 225 on Subscriber Service Card.

Rate Analyzer Offers Solution to Test Problems



Schmeling Electronics has in production their Model 140 Universal Relay Analyzer. This test instrument provides fast accurate testing of relays under actual contact loading, including dry circuit switching, according to the company.

Model 140 checks every phase of relay operation as follows: precise check of pull-in and drop-out voltage, exact measurement of contact make and break time, accurate evaluation of contact bounce, overlap time on make-before-break and break-before-make contacts, and contact resistance measurement with simultaneous observation of all relay contacts.

A cycling circuit permits automatic cycling of the relay at a rate selected by the operator. Adapters to accommodate various relay types may be plugged into the front panel. These are designed so they may contain switches for special measurement, such as analyzing relays with 8 form "C" contacts.

Accessories supplied include a universal adapter with wire leads and miniature alligator clips, connector for external contact power supply and contact loads and instruction manual.

General specifications includes—Input: 117 volts, 60 cps, 180 watts. Size: width 13", height 16¾", depth 18½".

Circle No. 233 on Subscriber Service Card.

Timer Measures Billionth of a Second

A timing device that measures time intervals as short as a billionth of a second has been developed by Eldorado Electronics Co. The new instrument, known as "Nanosec," extends the art of time measurement three orders of magnitude from the millionth of a second range possible with present equipment. A billionth of a second (or nanosecond in the metric system of measurement) is the time it takes light to travel approximately three feet.

Intended originally as a nuclear research tool, "Nanosec" can be used in the fields of radar, computer and solid state physics where requirements have outstripped the ability of conventional instruments. "Nanosec" applications include neutron time-of-flight measurement, determining the half-life of short-lived radioisotopes, fast-coincidence circuit studies, delay line calibration in radar circuits, and transient time studies.

"Nanosec" consists of two basic elements—a time-to-amplitude converter and a 20 channel amplitude analyzer. In use, a time interval under measure is converted to a pulse of proportional height. The pulse height is measured by the amplitude analyzer and registered in one of the analyzer channels. Each channel corresponds to a known time interval. By noting which channel registers, the operator can determine the time interval.

Circle No. 238 on Subscriber Service Card.

Phase-Lock Discriminator Features Modular Design

Hallamore Electronics Co. has developed a phase-lock discriminator in building-block form. The unit, HEC-0162, eliminates suppression of signals by noise, non-linearities introduced by filtering, and thresholding at low signal-to-noise levels.

The company says operation in missile data reduction centers has demonstrated the capability of the discriminator to produce reliable data at

S/N ratios, which renders pulse-counting type discriminators inoperative.

The HEC-0162, one in a series of building-block components, is said to simplify operational procedures, afford economy in mounting space, eliminate system errors and provide a near-optimum information handling efficiency.

Standard production models include all IRIG channels, including the optional wide band (15% deviation) channels. Non-standard discriminators are fabricated according to customer requirements.

Circle No. 248 on Subscriber Service Card.

Electromagnetic Transducer Accurate to 1 Sec. of Arc

Sterling Precision Corp. is producing a new T833 transducer—a differential transformer type pickoff consisting of an E-Core stator and one or more separate companion rotors. The transducer, or "E Coil," is accurate to 1 sec. of arc and is used in position pickoff in servo rate or optical systems.

Although primarily designed as a positional trip on Sterling Test Turntables, the unit may be adapted for use as an electromechanical transducer for precise measurement of both linear and angular displacements.

The dimensions of the Sterling transducer in potted core are 1½" x ⅝" x ½" high, while in potted housing the dimensions are 2" x 1½" x ¾". The rotor face is .250" diameter round or .250" square. Excitation: 5 to 100 ma/300 cycles to 2 KC. Sensitivity is measured at 0.1 ma per .001" per ma excitation at 400 cycles.

Circle No. 251 on Subscriber Service Card.

Improved Data System Now Available

Beckman Systems Division is producing a new data processing system, the Model 123. The system has been designed to meet the needs for a high quality data handling unit, retaining the concepts of reliability and accuracy in processing.

The Model 123 is equipped to scan 100 points at the rate of one per second. The system provides 25 combinations of scaling and zero off-set, high or low alarm limits and square root extraction for flow measurement computation.

It utilizes the same components as the Beckman Model 112 Data Processing Computer, using transistors throughout, sealed stepping switches, and all solid state components. Programming is simplified by use of the Beckman Systems pinboard. Cost has been kept to a minimum in the Model 123 by manufacturing the system as a standard item rather than a custom item.

Circle No. 249 on Subscriber Service Card.

Centrifuge Slip Ring Used For High-Voltage

A new centrifuge slip ring designed for use with exceedingly high-voltage has been produced by Slip Ring Company of America, Los Angeles.

It has three high-voltage circuits capable of 10 kv dc, continuous and was tested at 20,000 volts hi-pot. Instrumentation circuits are unaffected by adjacent high-voltage circuits. Minimum noise is accomplished by the use of precious metals.

Dual brushes, riding on each ring and tuned to different resonant frequencies, provide uninterrupted circuits. The assembly is rated at 350°F continuous operation. All 15 slip rings and shielded wires are high-pressure molded into one assembly.

Circle No. 245 on Subscriber Service Card.

Strip Chart Recorder Eliminates Inking Need

Mandrel Industrial Instruments has introduced the ER-20 direct-writing strip chart recorder for electrical data from dc to 100 cps. Coupled amplifiers give a sensitivity of 2 mv/mm.

Stylus deflection on each channel is 40 mm, with an accuracy of 2%. Electro-sensitive paper eliminates the need for any inking system. Easy paper loading and an electrically-controlled chart drive make operation simple.

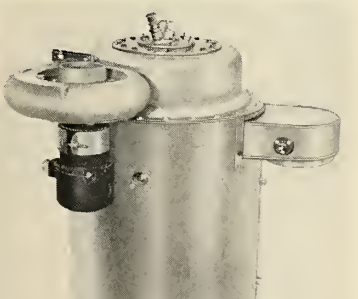
Circle No. 246 on Subscriber Service Card.

Mechanical and Materials

Million BTU/hr Heater For Ground Support

A liquid heater, with output variable from 0 to 1 million BTU/hr, has been designed to be extremely compact for missile ground support applications. The unit, manufactured by Janitrol Aircraft Division, automatically maintains liquid at any desired temperature. It operates as a complete heating system for such applications as missile-fuel heating during transfer, vaporizing, maintaining liquid temperature during storage, providing personnel comfort heat in building and support vehicles.

The heater stands 46½" high, is 18¼" in diameter, and complete with controls weighs about 257 pounds. Radio noise shielding meets the requirements of MIL-1-11683 and it will operate in extreme environments to −65°F. Designed for multi-fuel use, the liquid heater can be adjusted to burn either fuel, gasoline, or JP-4.



In use, the heaters may be operated individually or may be combined in modular units to meet virtually any requirement for large amounts of controlled heat. The heater operates at 75% efficiency. Units are designed for easy access to all parts for servicing and maintenance.

Automatic holding of a predetermined temperature is accomplished by cycling the heater. Controls operate on 24 volts dc. In addition to the heater itself, a complete unit includes a fuel train bracket which incorporates a filter, a positive displacement fuel pump, a pressure regulating fuel valve, a solenoid valve, and a fuel pressure gage.

In addition, a 4½"w x 3½"d x 6½" control box contains a circuit breaker, ignition vibrator point selector switch, and a safety switch which cuts off the unit in case of failure in ignition, fuel flow, or air flow. The safety cut-off switch also lights a trouble warning lamp.

Standard models are furnished with a cycling switch set to cut out at

195° ± 50°F. Cut-in setting is 180° ± 5°F. A high limit switch is set to cut out at 210°±5°F., and automatically restarts the heater when liquid temperature drops 10 to 20 degrees lower than the cut-out temperature.

Circle No. 253 on Subscriber Service Card.

Relief Valve Features Light Weight, Compactness

Bendix Aviation Corp. has developed a new line of hydraulic inline unbalanced relief valves designed for light weight, compactness, simplicity and maximum performance.

The valves conform to MS28887 Type II envelop, and are designed to meet or exceed MIL-V-5523B and the proposed "C" revision, Type II specifications (reverse flow excepted).

A special compensating design feature allows use of extended flow rates. As high as 4.5 times MIL-V-5523B rated flow has been accomplished without exceeding the allowable pressure differential.

All valves have been fully qualified from −65°F to +275°F. Adjustments for maximum pressure settings range from 500 to 3850 psi, and can be made available as high as 4850 psi. Readily available from stock are ¼", ⅜" and ½" tube sizes.

Circle No. 227 on Subscriber Service Card.

Heavy Duty Cylinders For Automated Equipment

A new line of heavy-duty air and hydraulic cylinders, especially designed for use on automated equipment, is being produced by the S-P Manufacturing Corp.

The general purposed heavy-duty cylinders have pressure ratings of 200 psi (air) and 1000 psi (hydraulic). They are offered in nine sizes and in five mounting styles: flange (blind end), flange (rod end), clevis, adjustable trunnion and foot. Sizes range from 1½" to 8" bores, with strokes to customer's specification.

All models are available non-cushioned, cushioned blind-end, cushioned rod or cushioned both ends. Mounting dimensions of cushioned and non-cushioned cylinders are identical. Cushion check and cushion adjustment may be interchanged without further cylinder modification.

According to the manufacturer, high performance and long life, with minimum maintenance, are assured by the design and construction features of the cylinders. Honed seamless steel barrels, steel and plates; and heat treated low carbon, low alloy steel piston rods are structural features of the units.

A radius at the end of the rod thread prevents stress concentration and facilitates installation of seal cartridge. Large ports provide fast cylinder operation, and alternate port positions are available. All ferrous parts are rustproofed for resistance to corrosion.

Piston and cartridge-retained rod seals are designed for operation at temperatures ranging from −20° to 150°F. Special seals for higher or lower temperatures and piston ring construction, for hydraulic cylinders only, are optional.

Circle No. 235 on Subscriber Service Card.

Regulator Prevents Electronic Destruction

A specially developed air pressure regulator, used to prevent self-destruction of electronic guidance equipment on guided missiles, is now being produced by the Garrett Corp.'s AiResearch Manufacturing Div.

The regulator maintains approximate sea level pressure in an electronics compartment. Without this environmental control, the equipment would be subjected to destructive electrical arcing at the low pressures of high altitude. The unit weighs just ¾ lb., measures 3" high, with a housing diameter of 2¼" and an attachment flange diameter of 4".

Essentially, the unit is an outflow valve operated by a spring and bellows arrangement. The interior of the bellows is evacuated to approximately zero pressure. As the unit is carried to higher altitudes, faster flow of gas from the compartment to the atmosphere results in lower compartment pressure on the bellows. This allows the bellows to expand with the assistance of the spring.

The resulting action positions the valve to lessen the opening that permits flow to the atmosphere. In this manner, the gaseous environment of the chamber is kept in circulation at a constant pressure position.

A unique feature of the regulator is the mechanical connection between the bellows and valve, rather than a pneumatic connection as used in other units.

Circle No. 240 on Subscriber Service Card.

Dexterous Missile Gear Handles One Hundred Tons

Industrial Products Engineering Co. has developed a new type of missile-handling equipment to accommodate weights ranging from one to one hundred tons. The equipment, intended for use in plants engaged in missile manufacture and assembly, accommodates cylindrical objects by use of a circular "shoe." It picks up missiles in a horizontal position and rotates them to a vertical position for additional work or assembly.

The electrically-operated unit travels on an overhead track to deliver missiles to various parts of an assembly line. Using a uniquely designed type of closure, the shoe (together with a support shoe) can pick up and manipulate missiles in various positions without the need for support structures or external rigging.

Circle No. 257 on Subscriber Service Card.

Temperature Probe For 3200°R at Mach 5

Aero Research Instrument Co. Inc. has developed a total temperature probe for operation up to 3200°R at Mach 5.0.

It is made through the use of a

new metal process that promises to lend itself for other high temperature measurement applications, i. e., ram jet and afterburner exhaust.

The probe uses a platinum 13% rhodium-platinum thermocouple. Actual wind tunnel data shows a recovery factor close to unity at 70,000 feet. Missile use has been at altitudes of at least 2 x 10 feet. and has survived re-entry.

Circle No. 242 on Subscriber Service Card.

GE Markets Series of New Silicone Compounds

General Electric has added three new general purpose silicone rubber compounds to the standard product line of the Silicone Products Department. Designated SE-452, SE-472 and SE-482, these meet or exceed MIL-R-5847C Class II specifications.

Tensile Strengths of 800 to 1,400 pounds per square inch, tear strengths of 80 to 200 pounds per inch, and elongations of 250 to 550% are obtainable with all three compounds. Properly cured parts fabricated from these compounds exceed the appropriate tensile strength requirements of MIL-R-5847C by 23 to 54%.

SE-482 is said to offer greater tensile strength than any other commercially available 80 durometer silicone rubber, and is best suited for fabrication by molding and calendering. It may be blended with the softer SE-452 to obtain compounds of intermediate hardness.

SE-472, a 70 durometer hardness stock, and SE-452, a 50 durometer stock, have excellent processing characteristics, according to GE, and are especially suited for fabrication by extrusion. SE-472, which meets the standards of AMS3357 as well as those of MIL-R-5847C, is also well suited for calendering.

All three rubbers may be used in extended service over the temperature range of –75°F to 500°F. Although manfactured as white compounds, they may be tinted during fabrication to obtain a wide variety of colors. SE-452, SE-472, and SE-482 are available in commercial quantities.

Because of their good physical characteristics, which include very low water absorption and resistance to compression set, these general-purpose compounds are suggested for a wide variety of sealing, gasketing and mechanical applications in various phases of missile and aircraft manufacture.

Silicone rubber room-temperature-vulcanizing (RTV) compounds, capable of being poured or spread in place, have been developed by General Electric. The compounds can fulfill a wide variety of caulking, sealing, patching, encapsulating, and potting application on missiles and on the various components used.

The RTV compounds do not require the heat cure ordinarily used for silicone rubber, but GE says they possess much of the long term heat resistance and low temperature flexibility unique to silicone rubber. In addition, they exhibit the silicone's outstanding resistance to ozone, weathering and aging.

Because they may be poured or spread in place, compounds 80774 and 81813 are readily used in sealing, filling irregularly shaped voids, and covering components for which molded or extruded parts are difficult or impossible to fabricate. Bonding of these compounds to aluminum, copper, stainless steel and other metals; and to other materials such as glass, ceramics and plastics is easily done. Such bonds are actually stronger than the elastomer itself at temperatures as high as 625°F.

Circle No. 228 on Subscriber Service Card.

Heat Exchanger Cools Guidance System Tubes

In ambient temperatures from —65° to +135°F; from sea level to 10,000 ft., mounted unsheltered on an off-the-highway portable vehicle, this unit, developed by Lear, Inc., is designed for cooling a klystron tube associated with the ground guidance systems of missiles.

Under adverse conditions, while maintaining a controlled liquid outlet temperature of 170°F plus or minus 5°F, the unit has a nominal heat dissipation rate of 6000 watts.

Both electric motors are continuous duty, 208 volt, 3 phase, 400 cycle. The pump motor is 0.5 hp at 2600 rpm, and the fan motor is 1.25 hp at 11,000 rpm. At 2,600 rpm the liquid flow rate is 2.6 gpm with a 170 psi cooler differential pressure.

Safety features include a pump relief valve to by-pass full flow at 245 psi gage cooler discharge pressure, and a safety heater thermostat set to open at 300°F. For liquid preheat prior to energizing the electronic gear, the unit includes a thermal by-pass system which prevents liquid flow through the external system below 100°F.

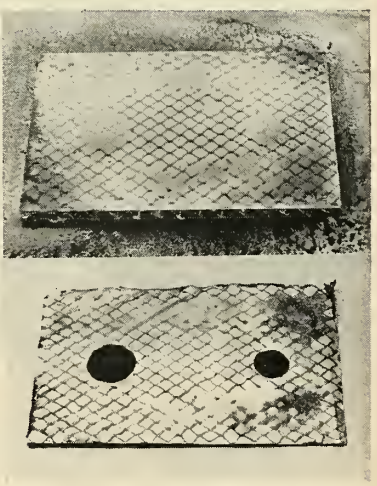
Circle No. 250 on Subscriber Service Card.

Kit Locates Lack of Bond In Honeycomb Structures

A method for checking the bond in honeycomb structures is available in kit form. The Bondcheck BC-1 inspection kit is used on metallic honeycomb, soldered, welded or brazed-to-the-skin surfaces.

The test procedure includes cleaning the part surface and spraying on a specially formulated red fluid that is repelled by heat and tends to flow to the coolest area on a metal surface. A controlled heat is then applied from a high intensity infrared lamp.

This heat is conducted from the inspected surface to the honeycomb core wherever good bond exists between the core and surface. Since the visible fluid flows to the coolest areas, it accumulates at every point of good bond, reproducing an exact pattern on the bonded area. Areas of defective bond are visible as gaps in this pattern.



The upper photo shows Bondcheck indications of honeycomb patterns. Void areas reveal lack of bond between skin surface and honeycomb core.

In the lower photo, removal of outer skin shows actual defective core and verifies the accuracy of Bondcheck's pattern.

Deformed core materials are also readily apparent, with the inner core pattern visible in the outer surface pattern. The test takes only a few seconds per area tested. Any complex shape can be tested, and automatic testing is practical on simple shapes.

Circle No. 247 on Subscriber Service Card.

NAVTAC: "Pipeline" to a happy landing

The uniqueness of the new NAVTAC en route navigation and instrument landing system by Stromberg-Carlson is in its *combination* of functional modules.

The NAVTAC equipment is an assembly designed to provide high-performance aircraft with the TACAN navigational aid, plus marker beacon receiver, glide slope and runway localizer for instrument landing situations.

The entire system is packaged in a compact unit only 5″ high, 10½″ wide, 22″ deep, and weighing only 47.5 lbs. Individual modules can be separated up to distances of several feet without any adverse effect on performance.

The equipment is designed to meet the rigorous environment of the high-performance aircraft of today and tomorrow. Its operating ambient temperature range is −60 to +125 degrees C. at altitudes up to 70,000 feet. Widespread use of semiconductors in the ILS receivers and TACAN circuitry means high reliability, small size and low power consumption.

Included in the design is the capability of performing complete preflight confidence tests with the use of a small auxiliary test set.

Complete technical details on the NAVTAC system are available on request.

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Selling Subsystems

by Seabrook Hull

Like other phases of the rocket, missile and space flight business, selling subsystems and major components is primarily a marketing and sales problem.

Analyze your market; figure out where you fit in; where you want to be ten years hence; and then get out and do some old-fashioned hard selling.

If personal, inspirational selling is no longer necessary in consumer goods because of a Madison-Avenue-kind of mechanization, that's no indication that missile business can be had the same way. With missiles, competition is reminiscent of the early depression thirties—just as keen and just as cut-throat.

If you're selling a subsystem, you make your major parts of a missile system. This doesn't mean that you must have as big a technical staff as the prime systems contractor. But it does mean that you must understand his problems thoroughly, and you must have a technical staff sufficient to research and develop your portion of the job.

• **How to sell**—You cans ell subsystems either as a prime or a subcontractor, though more often than not it's the latter. Generally, you're a prime in the production stage; a sub in Research and Development. The Army used to place all its subsystems contracts as prime contract work, retaining overall systems responsibility within an Army Arsenal. However, the Army, Navy and Air Force now almost always places the initial research and development prime systems contract with a commercial prime contractor. Thus, to get subsystems business you should go to the company with the prime contract.

This means knowing who is going to get the contract in advance. You've got to be on the road ahead of time—talking, listening, prying, calculating.

It boils down to this: The first step in selling is to know your market. The way you get to know this market is to get around.

It pays to make calls. Once you've settled on a project in which you want to be a subsystem contractor, and you think you know who's going to be placing these subsystem contracts, go visit the lucky company.

Walk in armed with as much knowledge as possible of the whole project, and an ever better knowledge of the part you want to play. Offer suggestions—backed by engineering knowledge—of how to do the job better: how to put reliability and low cost into guidance, how to make all ground support mobile, how to get 40 more points of specific impulse out of a real simple, inexpensive solid propellent engine.

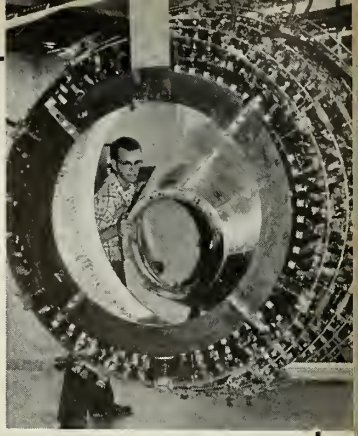
So, you get in on the ground floor as a major subsystems contractor at the R&D level. And, you think you're set. Well . . . maybe.

• **Pitfalls**—Loud and pitiful have been the howls in Washington from companies who held the initial subsystem contract for a missile and who carried through the research, development and prototype stages, only to lose the production contract.

In part, their howls are justified. A contractor might have taken a subsystems job on a cost-plus-fixed-fee basis, only to find that change-orders had tripled the cost, while the fixed fee remained fixed. Thus, planned percentage on gross was cut to one third.

Government, however, takes a different view, charges that too many companies with initial R&D contracts try to make a killing on the first production contract, and thus lose out to lower bidders. Best advice: Don't count chickens until you've got a good idea of what your competition is willing to do.

• **Group bidding**—Subsystems contracting is a highly responsible business. It is every bit as important as prime systems work. This is evidenced by the growing acceptance of the group method of bidding.



Chrysler Corp.

Here, the subsystems contractor becomes a responsible part of the prime contracting team. This is where a group of companies with complementary capabilities bid on complete systems as though they were a single integrated company team.

Navy in particular favors this approach by industry, especially with missiles that are going into production. However, there are a few things any potential group should keep in mind. First are "responsibility" requirements.

Any contracting office is properly concerned with whether the individual companies in the group are legally compelled to carry through, once committed. The fear is that if one of the companies should decide to drop out part way through a program, the whole project might be endangered.

Two other requirements for the group are that it have some kind of clearance, perhaps from the Justice Department, indicating that it is not in violation of any anti-trust laws; and that member companies will abide by decisions of that part of the group vested with systems responsibility.

With these assurances and with the right balance of technical, scientific and industrial resources, a subsystems contractor can move into the prime systems field. The next step after successfully participating in a group project could well be to bid for and win a prime systems award.

Meanwhile, remember: Subsystems are a lot more competitive than prime systems. But the prize is worth the run, since those who establish their reputation now will have a head start in the coming age of production missiles and space flight projects.

Atlas Testing

Sub-systems on trial in captive firing stand

STATIC FIRINGS of the *Atlas* ICBM at the Sycamore Canyon Captive Missile test facility of Convair-Astronautics and at Edwards Rocket Base are credited with the relative success of the *Atlas,* according to Col. Otto Glasser, assistant deputy commander for weapons systems, Air Force Ballistic Missile Division.

"Without these facilities we wouldn't have been able to get *Atlas* off the ground at Patrick AFB," he added, "and the program probably would have been cancelled for lack of success."

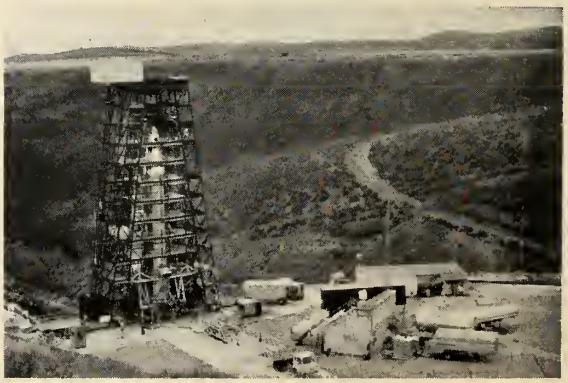
The Sycamore Canyon static firings began on "X-minus-1," the wing-shift of the day before the test was scheduled. On the morning of the test day, the test crew started a four-hour cutdown of about 4,000 items. In actual military operations, minus all the development and test equipment, an *Atlas* can be fired in a matter of minutes.

Although the launch procedures, test equipment and related ground equipment have been checked out during each static firing, additional firings will be made in a few weeks at Cooke AFB. Construction of the new launching test site is moving rapidly.

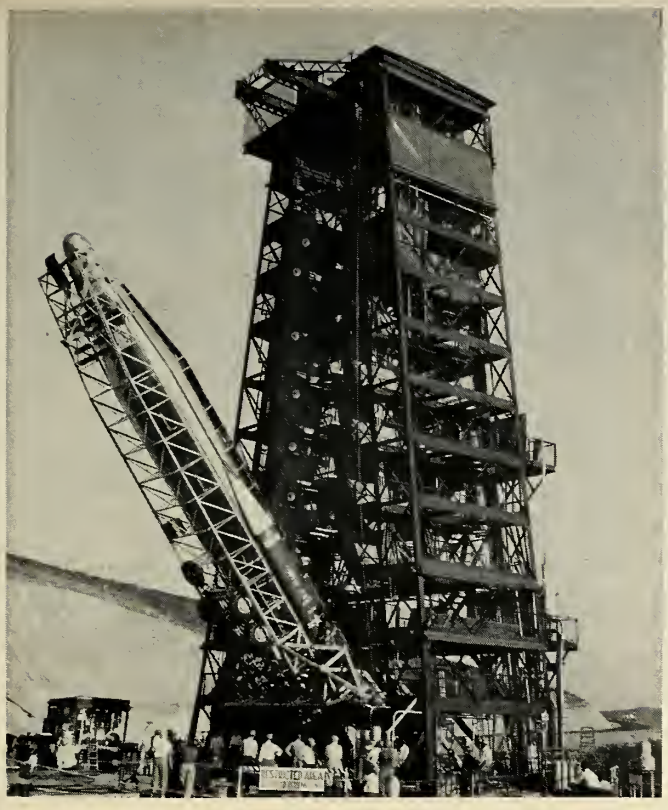
When the Cooke pads are completed, they will serve two purposes: the facilities will be to train *Atlas* crews, and carry out actual launching of missiles into the new Pacific Missile test range. In addition, the Cooke tests will enable the Air Force and Convair-Astronautics to polish up the design integration and guide the configuration of future sites, such as those to be built at Warren AFB, Cheyenne, Wyoming.

When the *Atlas* goes into production, it will cost about $1.7-million per unit, but present costs are in the neighborhood of $2-million.

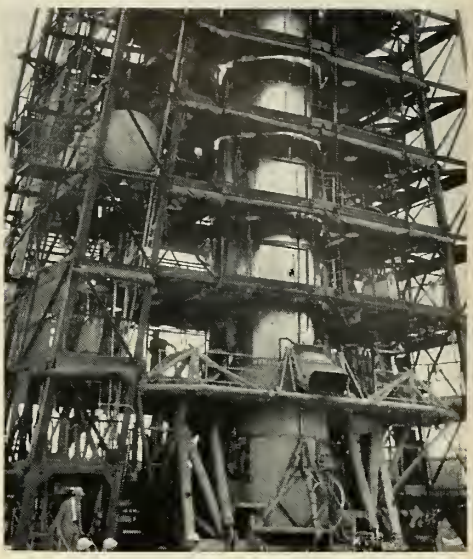
A SHROUDED *Atlas* missile arrives at Convair's Sycamore Canyon facility for captive testing. Part of the two-level reinforced concrete blockhouse, which serves as a test control station, can be seen at upper right. Liquid oxygen propellant for the missile is stored in a tank behind bunker.



FINAL PREPARATIONS are made for a "hot" run. The two small tanks to the left of the bunker (right foreground) are used during pressurization tests. Liquid nitrogen and helium trailers are stationed to the right of the bunker. Other equipment sheds and vehicles are grouped near the stand.

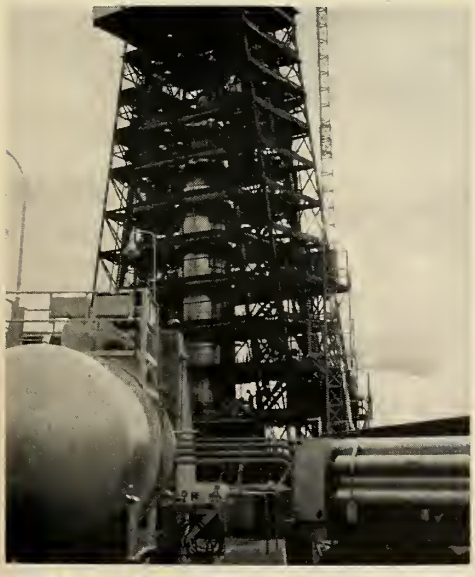


RESTING on its handling trailer, an *Atlas* is raised into static test stand. The trailer transports the missile from the San Diego plant of Convair-Astronautics to Sycamore Canyon and Cape Canaveral.



IN A CLOSE-UP view, the flame deflector (for testing only) of one of the missile's two vernier engines is plainly visible. Thrust measuring devices are located at the base of the 100-foot-high service tower.

HUGE STEAM CLOUD dwarfs the tower during captive testing. Steam is generated as exhaust strikes a water-cooled deflector. Water pours over the deflector at 30,000 gallons per minute.



PROPELLANT TRANSFER facilities pump LOX and RP-1 fuel at rates up to 1,000 gallons per minute. 30,000 gallons of LOX and 16,000 gallons of fuel can be stored at the testing facility.

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- Small portable field units to cool huts filled with electronic gear for missile ground support, battlefield television, communications and radar (bulletin 106)
- Conditioning systems for Radome shelters (bulletin 108)
- Mobile cooling units for trailer-mounted electronic systems for missile and aircraft ground support (bulletin 111)
- Units to cool automatic landing devices for carrier and land-based aircraft (bulletin 122)
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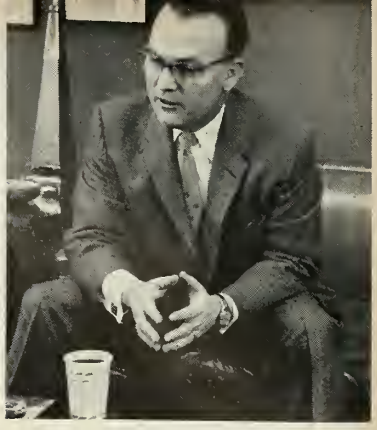

". . . we must create an atmosphere of greater freedom . . ."

". . . I was quite hopeful that we would get more cooperation . . ."

Q. Congressman, what are the ultimate goals of your Committee?
A. I think we have to create an atmosphere of greater freedom for the men employed on science and defense projects. There should be honest-to-God cooperation and coordination between the military departments, and a civilian agency to direct and supervise the type of research we will undertake, so that the tendency of the military departments to hold on to every bit of knowledge they develop is brought to an end. I think we're still spending far more than necessary in duplicating research. This is true of missiles or any other field where we have to make advances and breakthroughs in scientific knowledge. This is what our Committee is looking into.

Q. Can you give us any idea of what action might be taken to rationalize the security program? Can you do this legislatively?
A. It can be done legislatively. It will take much more time; it will be much more difficult. It should be done by administrative action or through a coordinated program recommended to the Congress by the executive. There is no substitute for an informed and a fully responsible executive in this or any other field.

Q. You've got a Democratic Congress and a Republican administration—which always leads to a bit of friction. Do you see any signs that the executive, i.e. the administration, is going to do this on its own?
A. Signs are so faint as to be almost non-existent.

Q. Which throws it back in your lap again?
A. It throws it back in our lap. We're handicapped because we haven't immediate access to the information we need to make a sound decision.

Q. Has there heen any proposal made for instituting—passing a law—which would specifically define the rights of the public and Congress in limiting classification?
A. No. because that's much more difficult than it sounds. In fashioning such a law, or trying to spell out precisely what the public can know, legislation will not be easy. In the first place, I think the rights of Congress are inherent in the Constitution and all Congress needs to do is move forward in asserting its rights, demanding that they be recognized by the executive.

Q. Aside from taking such forward action have you come to face with a dilemma? Have you talked with McElroy on this subject?
A. No, I haven't talked with McElroy. I might add that we tried to work cooperatively with the office of the Secretary for the first two and a half years of the Committee under Secretary Wilson. We made little progress. We haven't had occasion to contact Secretary McElroy. That may be a matter for action in the near future.

Q. Do you have a feeling that you will get more cooperation from McElroy's office than you did from Wilson's?
A. I have stopped trying to determine the cooperation we might get. I was most hopeful that we would get more cooperation—honest cooperation—from the office of the Assistant Secretary, Mr. Snyder, than we had from his predecessor, Robert T. Ross. I can't honestly say that we have had more cooperation. I do feel that there has been a more skillful policy of management in Pentagon matters than under Ross. If we're going to be faced only with a more skillful handling of the problem but the same final result under Mr. McElroy as was true under Mr. Wilson, then we will have made little progress.

Q. Do you feel that more cooperation from the Pentagon is needed for your

Committee to do a proper job?
A. More cooperation is needed not only for my Committee to do a proper job, but the military itself will profit. When I say that, I mean that if the military would cut through this maze, of confusion and over-classification, it would be of tremendous importance to them in doing a better job.

Q. How can we change this attitude? Can McElroy himself change it simply by a directive, or do we need a whole new re-education program?
A. I think one of the ways we can change the attitude would be to again revise the rules and regulations regarding information from the Pentagon. They were revised following the reports of the Coolidge Committee and of the Commission headed by Lloyd Wright. The revisions in my judgment would be a tightening up of news rather than a freeing of it. When I use the term news, I use it in the broad sense—in effect—all information that might be of interest to anyone. I think the one thing we overlook is that we are not getting security as a result of these programs. We're only slowing down our progress in basic scientific development and in the application of scientific principles to weapons systems. I think the missile is certainly an illustration of that point. Another failure of these regulations is in attracting and holding the type of scientific manpower we desperately need in our research programs. We're discouraging our universities from taking contracts requiring classification. Universities feel that many of the classifications imposed are ridiculous; it is frustrating to their people and they just don't want anything to do with it.

Q. Could one of the problem points of classification be that we don't inform our people of information our intelligence organizations receive about the Russians?
A. Yes, it is. I don't think it's valid that the Russian MIG we purchased is still tightly classified. There are many things that are classified that are common knowledge to the Russian government. And sometimes I wonder what is the real objective of our classification system: to keep information from the American public, or to keep information from a potential enemy?

Q. Is it to protect those in power?
A. It's to avoid embarrassment and the need for explanation in many instances.

Q. Have you asked any of your witnesses how they justify this withholding of Russian information?
A. Oh, yes, we always get an answer. "If you let the Russians know what you're interested in, they will be in a better position to gauge your present rate of progress." I don't buy this, but it's offered to us time and time again. I think we could find out a great deal about the Russians if our government had a little more interest in translating and reading the information which the Russians make available to us.

Q. Is your Committee concerned with the lack of translations?
A. Oh, yes, we are looking into it.

Q. What have you found, so far?
A. You recall that we discovered the Rand translation of the Russian radio publication last fall had been completed considerably in advance of the *Sputnik* launching. Had our government read this information and informed the American people, we probably would not have been surprised when the Russians launched their first satellite. The publication gave the modulations of the transmission, what they would be measuring and what the measurements were. A week's time elapsed while our government was trying to determine the frequencies for the purpose of tracking the satellite. Yet this information was clearly published months in advance of the launching.

Q. Has Congress been able to get a detailed, comprehensive idea of the extent and rate of progress of the Soviet space flight program (to the knowledge of our intelligence data)?
A. It would be difficult for me to answer that. Until the Armed Services Committee and the Military Sub-committees on appropriations have reported to the House, I have no way of knowing how much information Congress has been able to get from the government. Of course, in this area, I feel that we definitely need a Congressional joint committee to supervise and review the activities of the CIA.

Q. Do you think the American public has been properly informed as to the potential significance and importance of space flight?
A. No, I don't.

Q. Has your Committee been given any assurance, or have you obtained any information of the type of program

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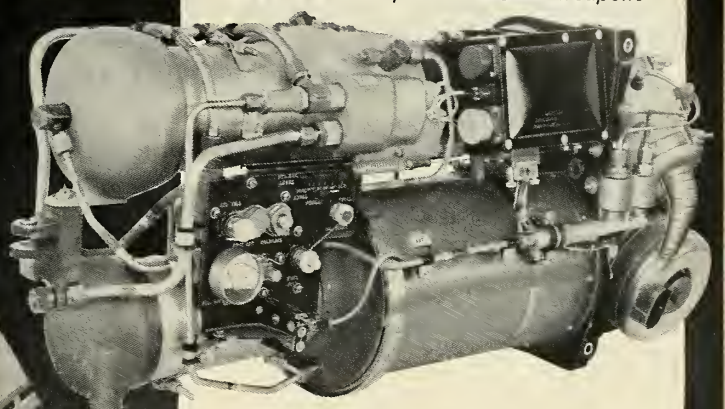

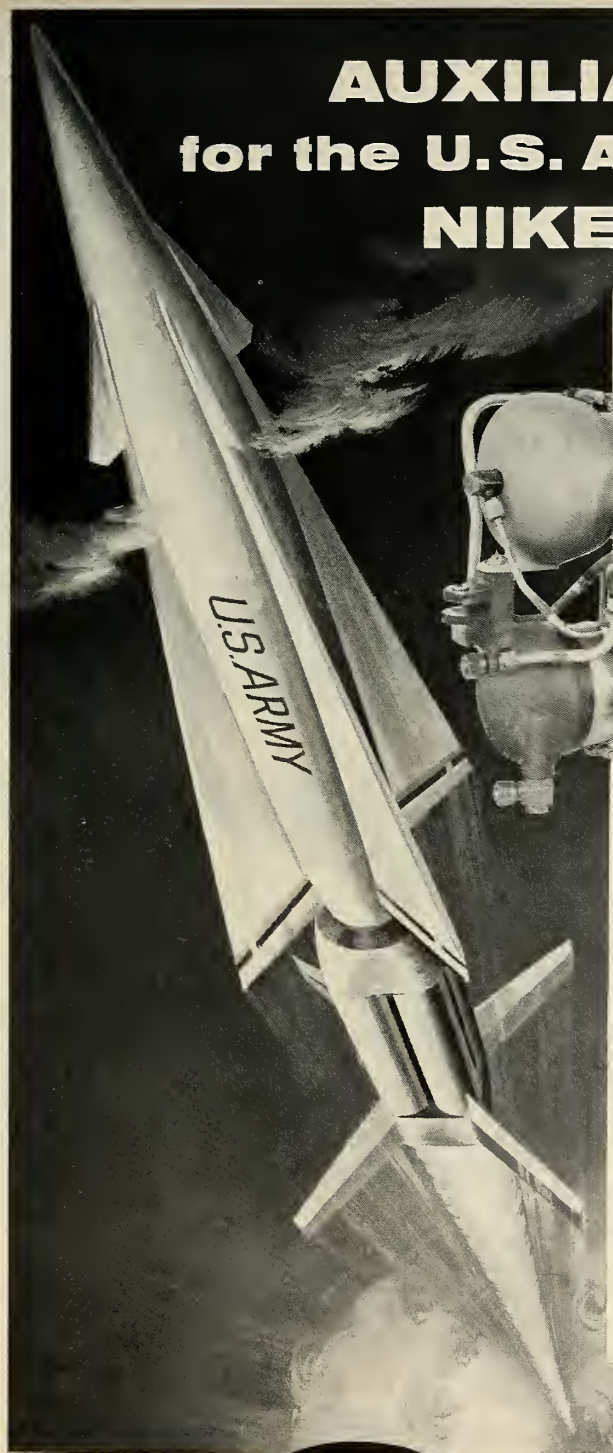

Key defense and population centers are now being ringed with batteries of Army Nike Hercules missiles to deter or destroy aggressors. *Supplying power for flight controls* is the AiResearch auxiliary power unit pictured above, now in production.

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Robert D. Grange

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Manager, Prototype Development Department

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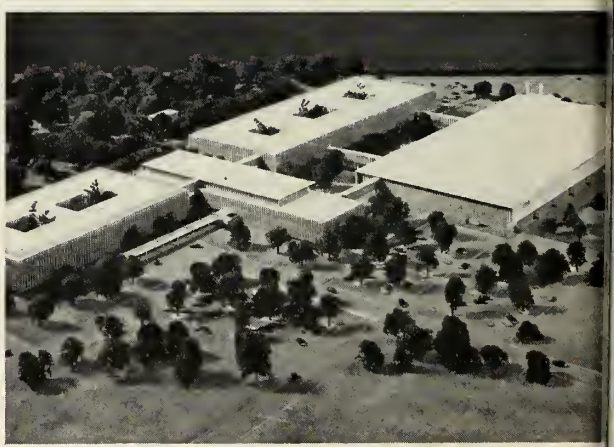

Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion this year, the ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

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our Advanced Research Projects Agency will undertake?
A. No, I haven't.

Q. **Concerning scientists—is the exchange of information within the security system a problem?**
A. Oh, I think it's very definitely a problem. Within the security system—even within one department—you may have a number of missile contracts in the Air Force. The information on these projects is not available even to a man who is cleared for that class of information. Again, you have to establish the need to know which is a very difficult thing to do. The fact that you are working on a top secret project for the Air Force does not guarantee that you can have access to all top secret information in that Department, even though the projects may be comparable. Between the services we've encountered the same barrier. The Air Force doesn't recognize an Army clearance. The Army doesn't recognize a Navy clearance. So we clear department by department, project by project and information is available only in the same way. Again, this complete compartmentalization both of manpower and of information is hampering our progress.

Q. **What are we going to do about it?**
A. Keep probing and needling; hoping that we'll be able to change their attitude. One thing that worries me—when the Japanese attacked Pearl Harbor, we had two years or so to get organized and get on our feet. Well, the Japanese made some bad mistakes. If they hadn't we might not have the two years. But we had a long period of time. If—today—anybody decides to push buttons, either literally or figuratively, we've got about 25 minutes.

Q. **In this particular instance, we don't have time to catch up when the chips are down. Do you see any hope? You've demonstrated we can't legislate. You also demonstrated that the executive itself isn't going to do anything about it. What's the "out."**
A. Well, that's a pretty tough question. I've been looking for that answer for two and a half years and I'm not prepared at the moment to say whether I have the solution. We're seeking it, we have ideas, but at the moment they're not in a form where we can legislate. We hope to take a 1789 statute enacted for the purpose of conferring upon the departments and agencies of government necessary authority to keep records—but which has now been tortured into an authority to withhold information—and restate in content the original intent of Congress. This statute gives the departments the custody, use and preservation of their records. They've used it to withhold—so we're merely adding language to the effect that this statute does not grant authority for withholding. We're having quite a bit of trouble. All of the executive departments are opposed to the amendment.

Q. **That will leave them authority for withholding information?**
A. It will leave them in my judgment, all the authority they need. It is specific statutory authority. Remember, this is in the field of nonsecurity information. There's sufficient authority, about 70 statutes, to permit them to withhold anything that is security.

Q. **On what basis can they decide it should be withheld?**
A. Anything can be withheld that is required by the government from business or industry reflecting trade secrets, or statistics of interest to the business or its competition. Of course, income tax can be withheld. The records of the FBI are protected. There's authority for just about anything the executive departments want to do in this field.

Q. **You're going to repeal this act?**
A. We're not going to tamper with the authority to manage records. But we are going to deny the executive the right under that statute to withhold information.

Q. **What effect do you think that might have?**
A. Specific authority will be needed for withholding. And in the process of getting authority, it will have to be justified. Where authority has been given, it will be necessary to specifically cite that authority and relate it to security.

Q. **Your Committee has made big progress on one point—the name of the Moss Committee shakes terror into many people at the Pentagon.**
A. The only criticism we have to that is—the name of the Committee is used, but the need to use the name is very rarely reported to the Committee. We would be able to do a much better job if we could know of the instances of withholding or refusing information encountered by reporters.

Q. **In other words, you invite those**

. . . confusing

kinds of reports?
A. Oh, we do—I should say we do! We can only investigate and call these departments which have refused. In every instance where we've caught them, it was as a result of a complaint filed with the Committee, or a tip-off to the Committee.

Q. I wonder if you have received any complaints on a problem that we're faced with all the time. We hear of a story and think it's a big scoop. When the story is checked with the Department of Defense, Army, Navy or Air Force, we're told "you can't write anything about this, it's classified." They promise to let us know later. In about a week a release is sent out, or someone gives a speech and breaks the story.
A. We would want to have those instances reported to us as soon as permission is refused.

Q. Would you say that you study all aspects of the security program? Are you currently concentrating within that field?
A. We are currently concentrating on scientific information.

Q. Are you having formal hearings?
A. We have had some hearings—we will have more hearings.

Q. Do you anticipate that you will publish your findings?
A. Oh, yes.

Q. Better not classify them.
A. They will be available.

Q. In your opinion, do you think the preparations for the *Vanguard* firing should have been less publicized?
A. You're thinking of the December 6th firing? I think the propaganda inspired by the Department of Defense was outrageous. It was completely wrong. But if you're talking about factual information, it was inadequate.

Q. Are you referring to the actual coverage by the newsmen of the event itself?
A. I think we're confusing propaganda inspired by the Department of Defense with factual information about the firing and possibility of success. The Defense Department failed to give a candid picture to the American people. If we're going to withhold information because of possible ill effects of the propaganda uses of it by the Department, we could withhold almost anything!

Q. Do you think the so-called propa-

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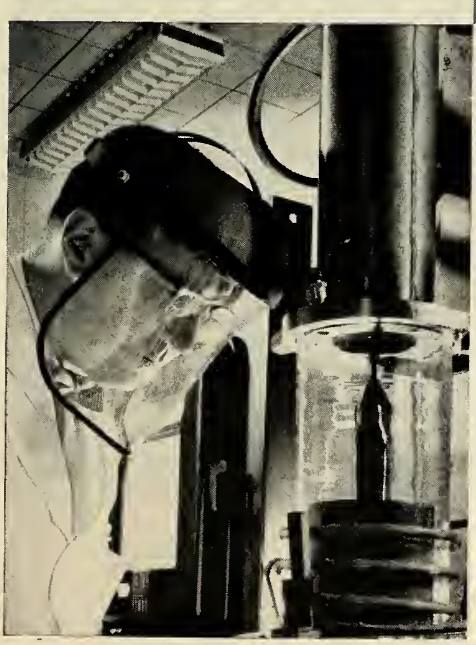

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THE ARMY'S NEW SERGEANT

JPL is proud to have the responsibility of designing and developing the U.S. Army's newest operational missile system—the Sergeant. This weapon is America's first truly "second generation" surface-to-surface tactical missile and, when placed in production will eventually succeed the Corporal which was also a JPL development.

The Sergeant, especially designed as an extremely mobile tactical weapon, utilizes a solid propellant rocket motor which provides better field handling and storage capabilities than those of many other weapon systems. It can deliver a nuclear blow deep into enemy territory and its highly accurate guidance system is invulnerable to any known means of enemy countermeasure.

All elements of the Sergeant are particularly designed for active field use with emphasis on reliability, mobility and the use of standard U.S. Army vehicles wherever possible. The erector-launcher, for example, is capable of rapid movement over rough terrain. These characteristics place in the hands of the U.S. Army an important new tactical element of extended range.

The basic activity at JPL continues to be—research into all scientific fields related to the development of weapons systems and space research vehicles.

. . . confusing

ganda on the *Vanguard* project might have influenced the Russians to step up their own satellite development?

A. I don't think so. I don't think there's any evidence that Russia has accelerated her program. I think when she launched her *Sputnik* she was already committed to a rapid course.

Q. In other words, the fact that we publish information about a certain missile or a certain satellite in the future would not necessarily mean that the Russians will step up their own program?

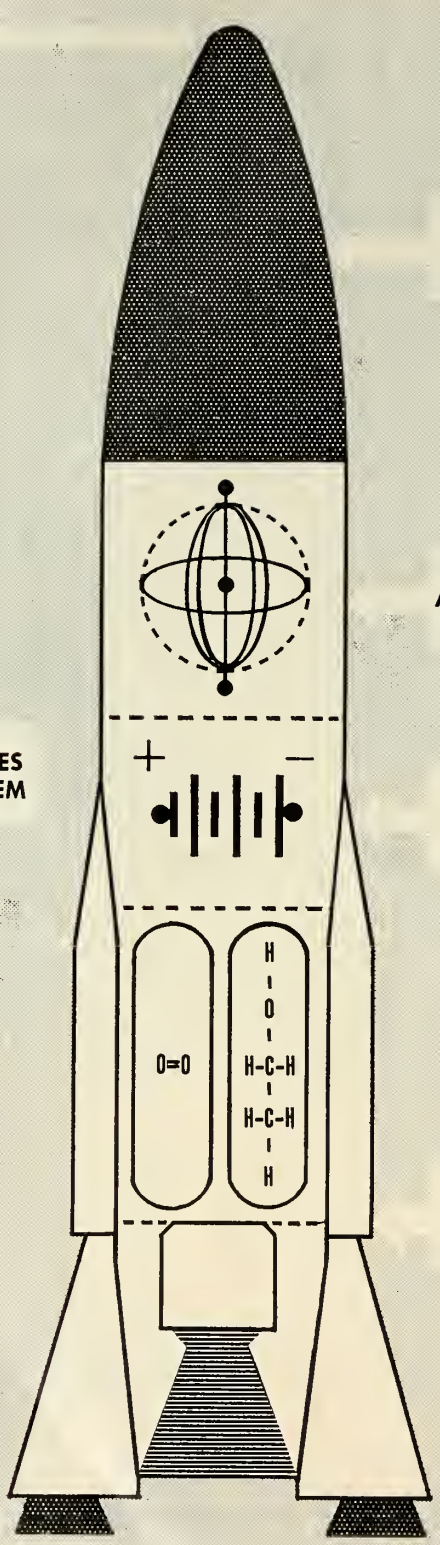
A. I don't think so. I think Russia has demonstrated that she has the sense of urgency which we apparently lack, and she recognized fully the impact on other nations of demonstrating superiority in this field. I don't think Russia's program is geared to what we might be planning, but it's geared to her ability to do a job. She's going to make us look bad just as quickly as possible. Whatever we do is not going to affect Russia's program.

Since this interview with m/r, the Moss bill telling the Executive Branch that it cannot rely on the 1789 statute for holding back information from the public and Congress, passed the House and has been sent to the Senate. It was passed by a wide bipartisan margin.

The 1789 statute authorizes department heads to regulate the "custody, use and preservation" of documents. But the House Subcommittee on Government Information, headed by Moss, showed agencies relied on this language to hold back information.

Shortly after passage, Moss said President Eisenhower's recent directive to the Secretary of Defense to strengthen the Defense Department's control over public information is "dangerous." Censorship of opinions or facts that fail to fit "policy" already has reached an "alarming degree" under Assistant Secretary Murray Snyder, Moss said. The President has explained his directive as a move to curb interservice rivalry.

Moss will be chairman of a panel on "Freedom of Information"—June 5 at the First National Missile Industry Conference, Washington, D.C. Sponsors are the American Rocket Society and the National Rocket Club.



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NACA Probes Fluorine Uses

Operational hazards of high-energy propellants studied at Cleveland facility

by Alfred J. Zaehringer

A $2.5-MILLION LABORATORY, the Lewis Rocket Engine facility, has been placed in operation by the NACA at the Lewis Flight Propulsion Laboratory, Cleveland, Ohio.

The new facility will be devoted to the development of new high-energy rocket propellants. NACA favors fluorine and has designed the laboratory with an eye to handling the hazardous and toxic material and its equally toxic exhaust. Components of the facility are: propellant supply and storage system, a thrust stand, silencing equipment, exhaust gas disposal system and an operations building which includes an instrument and control room.

Because of the high reactivity, handling fluorine is said to be more like working in a hospital operating room than in a machine shop. Fuels and oxidants, stored in tanks outside the test area, are brought to tanks near the test area, pressurized by nitrogen gas and then injected into the vertically mounted motor. The rocket motor fires directly into a closed silencer and scrubber. Current motors are at the 5000-lb. thrust level but this will be increased shortly to 20,000 lb. thrust.

NACA is currently studying injectors—presumably for fluorine combinations—and the parallel sheet blocks give about 90 to 95% of theoretical performance. Present blocks are machined from copper. Some of the fluorine engines look as if they are made of welded tubing for cooling purposes. However, NACA says two big problems have yet to be licked—the high combustion temperature (some 2000-3000°F hotter than the oxygen-hydrocarbon combinations) and the toxic exhaust (HF with most hydrocarbon fuels). It thus appears that the ozone rocket is considerably behind the fluorine hardware development stage.

NACA also has displayed two working models of ion rockets. One jet is produced in an arc chamber by striking a high electric current between a tungsten cathode rod and a graphite anode nozzle. A working fluid is injected and passed through the nozzle forming a plasma jet.

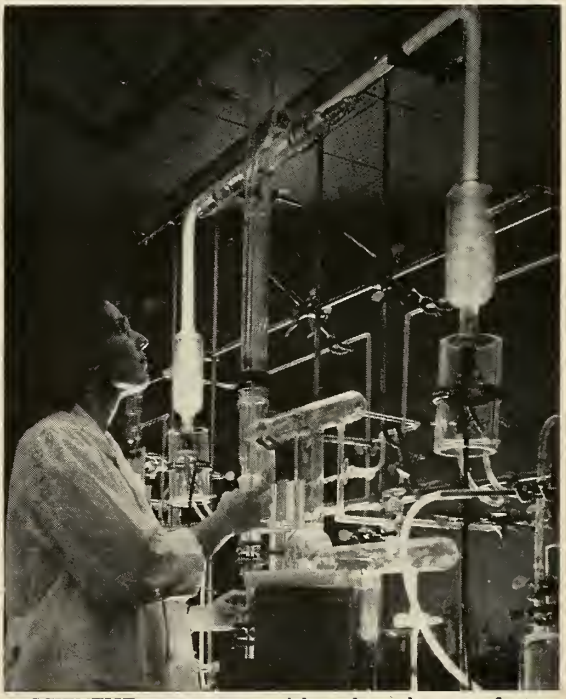
Streams of 10,000-20,000°F have

THE INSTRUMENT and control room of the Lewis Rocket Engine Research Facility is operations center during firings.

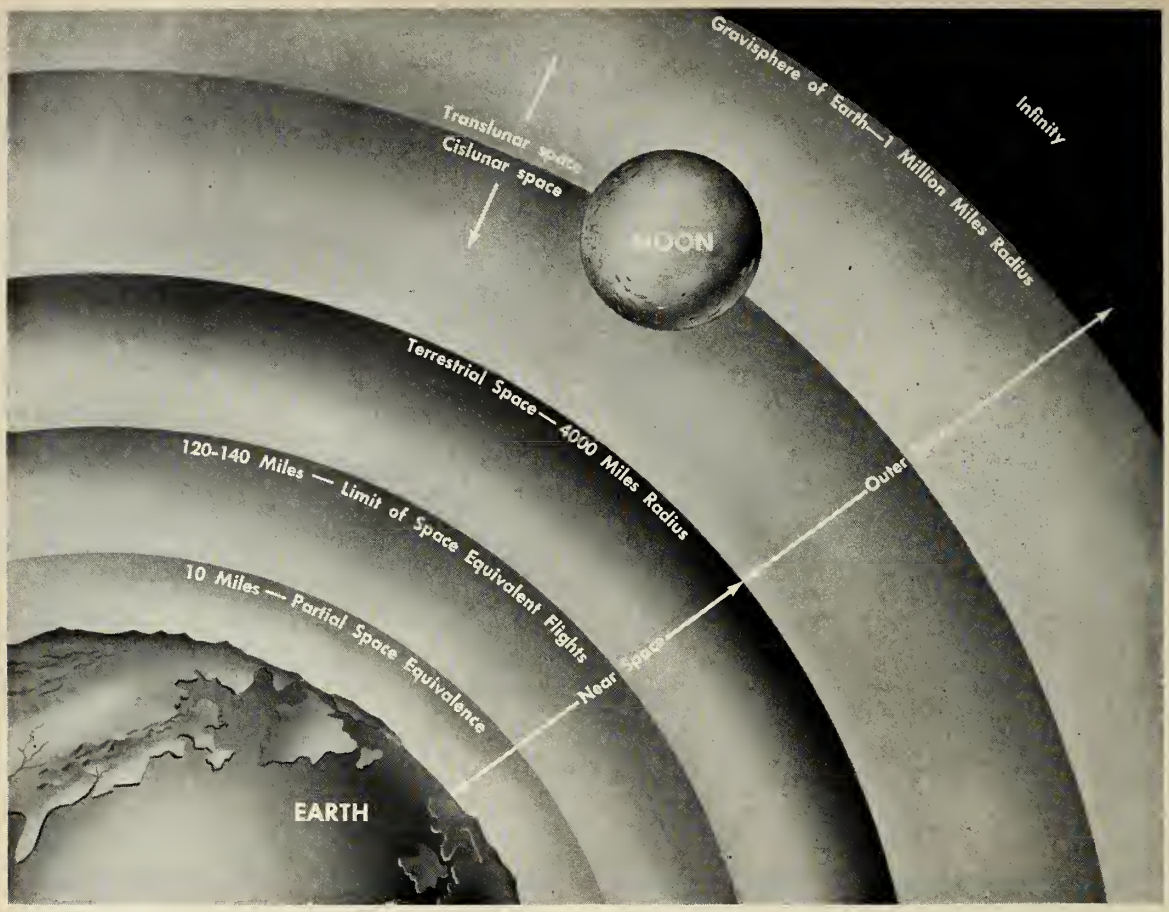
THIS "SCRUBBER" is part of the silencing and exhaust gas disposal system of the rocket engine static firing testing facility.

been produced and are currently being used to study the re-entry problem. The plasma jet is allowed to blast the nose cone of a missile model. Also demonstrated was an ion jet. Charged particles are formed in an electric discharge between two electrodes and are accelerated by a magnetic field. The thrust level was extremely small but large enough to operate a miniature low-mass pinwheel in a vacuum. Though NACA suggests both for outer space flight, it is agreed that package sizes to generate the necessary amounts of electrical power are still very unfavorable—especially considering that all such packages would have to be carried into space by chemical rockets.

A TECHNICIAN adjusts the valves on a research rocket engine mounted vertically within a test stand in the Lewis research facility.



A SCIENTIST compares materials under a barrage of atoms to determine which are more useful in missile and rocket manufacture.



Spatiography: Geography for Space

by Hubertus Strughold, M.D., PhD.*

NEVER BEFORE has the imagination of mankind been captivated so much by the concept of space. It is a concept that has appeared under a great variety of names: near space, outer space, deep space, free space, interplanetary space, cosmic space. But "space" is vast, even within our own solar system. From the standpoint of astronaustics, and especially of space medicine—or bioastronautics—we must specify just what is meant in terms of topography and environment.

Just as the traveler on the earth's surface used the science of geography for his orientation concerning the distance and conditions to be encountered on his journey, so does the astronaut need a topographical and environmental description of space. This might be called "spatiography"—for orientation, navigation, designation of the various kinds of space operations, and estimation of the medical problems involved.

At first glance, it may seem impossible to draw borderlines or demarcation lines for subdividing an environment distinguished by emptiness. There are, however, several possibilities.

• **Beginning of Space**—First question is "Where does space begin?"

This is the title of a paper published by the writer, with H. Haber, K. Buettner, and F. Haber in 1951, in which the concept of the functional borders between atmoshpere and space was introduced. In this publication, it was shown that the various atmospheric conditions necessary for manned flight come to an end at varying altitudes, some even within the lower regions of the stratosphere.

The final functional limit of the atmosphere is found at a height of 120 to 140 miles, where the atmosphere terminates aerodynamically. This is the dividing line between space-equivalent flights and true space operations—or between the aerodynamically effective air space and free space.

Now, what are the possibilities of subdividing, for astronautical purposes, the regions beyond this border?

**Advisor for Research, School of Aviation Medicine, USAF, Randolph AFB, Texas.*

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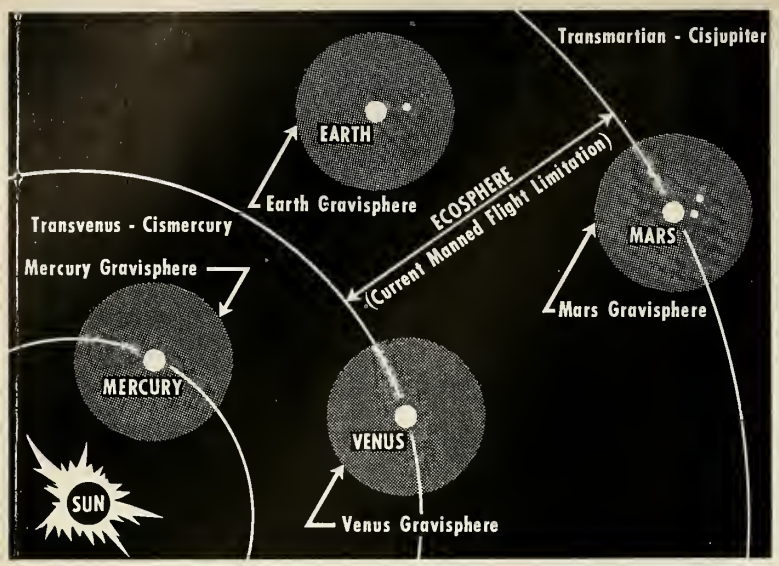

. . . Spatiography: Geography for Space

We can speak of cislunar space, translunar space, cismartian, and transmartian space, as Krafft Ehricke has suggested. (Cislunar on this side; Translunar space beyond.)

• **Gravisphere**—Of special interest from the standpoint of navigation is the gravitational situation in space.

The gravitational field of the Earth, as of every other body, extends, of course, to infinity—but for the astronaut, the sphere of predominant gravitational attraction is of most importance in navigation.

It might be practical to call these gravitational control zones gravispheres. The gravisphere of the Earth extends to about 1 million miles, this is the arena in which satellites are conceivable. Escape velocity eventually thrusts a vehicle out of the Earth's gravisphere into the gravitational control zones of other celestial bodies.

Thus we can arrive at an astronautical subdivision of space, based on the extention of the gravitational territories of the various celestial bodies.

Of practical and vital importance to the astronaut are differences in the environmental conditions of space itself: the space environment in the vicinity of celestial bodies is different from that in free interplanetary space. It shows some peculiarities caused by the mere presence of solid bodies, by optical properties of the surfaces of such bodies and by forces originating in these bodies and extending into space.

In the vicinity of the earth for instance, we are protected by the solid body of the planet itself from cosmic rays and meteorites—just as we are protected in the lee of a house from rain, hail or wind. Other peculiarities of space environment, near the earth, are shadow and radiation.

The forces that cause special regional environmental differences in the space near the earth are those of the geomagnetic field. The magnetic field of the earth strongly influences the influx of corpuscular rays of solar and cosmic origin, by channeling them into the polar regions. The density distribution of these ray particles in adjacent space, in fact, shows considerable variations with the earth's latitudes.

For all these reasons, space in the vicinity of the earth is somewhat different from open interplanetary space.

To emphasize these differences, Krafft Ehricke has introduced the concept of the "terrestrial space" and assumes for it an extension of 1 earth radius, or 4,000 miles.

"Circumterrestrial space" might be another suitable designation. For this region, within which the earth's influence upon the ecological qualities of space is distinctly recognizable, it might be advisable to use the term "near space," and for the region beyond, the term "deep space" or "outer space."

• **Solar Radiation**—But outer space again shows environmental differences in various parts of our solar system. These are based on variations in the intensity of solar radiation as a function of the distance from the sun.

A vehicle in the neighborhood of Venus would receive about fifty times as much heat per unit of surface area each minute than a vehicle in the area of Jupiter. This is an important factor in climate control within the space cabin. A vehicle fitted for a trip to Venus would not be suitable for an excursion to Jupiter, just as an expedition outfitted to hunt alligators in the jungles of the Amazon could not be sent to hunt polar bears in the Arctic. Any vehicle entering the intra-mercurian space would finally run into a kind of solar heat barrier.

With respect to visible radiation, or light, the "sky" in space is dark everywhere. However, the illumination received from the sun varies considerably. In the orbit of Mercury, it amounts to almost 80,000-foot candles while at the remote distance of Pluto, it is only 8 foot candles.

Finally, the ultraviolet range of solar radiation, which is chemically very active, has strongly influenced environmental conditions on the planets. This is shown by the division of their atmospheres into an inner oxygen belt, and an outer hydrogen belt. The first includes Venus, the Earth, and Mars. The second comprises the planets from Jupiter to Pluto. Spatiographic ecology, then, covers two areas: the ecology of space itself, and the ecology of the planets, or planetary ecology.

• **Ecosphere**—For manned space operations there seems to be—at least for the time being and in the near future—a limited area in the solar system with regard to the ecological conditions of space itself and the planets.

This is a kind of ecosphere, or a function of the distance from the sun and the resulting radiation intensities. This sphere includes the region from Venus to Mars.

We get a dramatic impression of the radiation intensity of the sun in both respects by comparing the size of the sun as seen from the various planets. For instance, from the distance of Pluto, the sun would not appear larger than the evening star (Venus) appears to us on earth.

For hundreds of years, astronomers have been mapping the stars, measuring the distances to them, and defining their motions. The astronomer performs these magical feats from afar while he sits behind his telescope in a well-tempered observatory, surrounded by the fresh air of Texas or California mountains.

By contrast, the astronaut will leave the life-supporting air of our planet and venture far into space, enclosed in his own little "earth." He has to know where he is going, into what physical environment. He needs as guide a "geography of space," or spatiography, based essentially on ecological considerations concerning space itself and the planets.

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2. **DEPENDABILITY.** Gas turbines are the simplest of all heat engines. There are few moving parts and no complicated cooling system. Overhauls are infrequent, maintenance is easy, routine servicing can be completed in a few hours.

3. **LIGHT WEIGHT, SMALL SIZE.** Solar gas turbines are many times smaller... and weigh up to *forty times less* than conventional engines! All essential piping and duct components are a part of the engine. There are few accessories and controls.

4. **PORTABILITY.** Compact and lightweight, Solar turbines can be easily mobilized for quick transportation to remote locations.

5. **ADAPTABILITY.** Versatile Solar turbines can provide power for virtually every phase of missile support—such as erecting and aligning, fueling, calibration, checkout and launching. Both shaft power and compressed air are available for important hydraulic, electric, mechanical, and pneumatic applications.

6. **USES ANY FUEL.** Solar gas turbines can operate on almost any available fuel—including gasoline, kerosene, natural or manufactured gas and diesel oil—greatly simplifying logistics for remote missile operations.

Portability, instant power and 100% reliability are continuing problems in the critical area of missile support. For more information on how Solar gas turbines can help solve these problems, write to Dept. F-11, Solar Aircraft Company, San Diego 12, California.

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Air on Mars?

Yes—But . . .

It seems pretty certain there's "air" on Mars—but it is in such small amounts that observers don't know how much.

In simple terms, the Mars visitor won't be bothered by the humidity, or by breathing either, for a long period. Both water and oxygen are present, but in such small quantities as to be virtually undetectable by present measuring methods. Same goes for gases like argon, neon, krypton and others.

Plants, like people, would probably find breathing a problem too, for the presence of carbon dioxide is still to be confirmed.

Telescopic observations suggest that Mars has an atmosphere similar, though more transparent than that of the Earth. For more specific information on the Martian atmosphere, astronomers have relied mainly on the spectrograph, though results so far have been inconclusive. The persistence of inconclusive results (despite increasing sensitivity of observing techniques) has led to lower estimates of the quantities of gases, such as oxygen, water vapor and carbon dioxide.

During the 1956 close approach of Mars, two husband-and-wife teams—C. C. Kiess, H. K. Kiess, C. H. Corliss, and E. L. R. Corliss—participated in an investigation sponsored jointly by the National Geographic Society and the National Bureau of Standards.

Using more sensitive instruments than ever before, scientists took their observations from the observatory operated by the U.S. Weather Bureau on Mauna Loa volcano in Hawaii. Other infrared spectrograms were made at the Georgetown College Observatory in Washington, D.C. The investigation concentrated mainly on a search for oxygen and water vapor.

Based on measurements, there is less H_2O in the Martian atmosphere than there is in a film of water 0.08 mm (1/300 in.) thick.

These results are not incompatible with the presence of water vapor in amounts sufficient to explain the transport of water from one polar cap to the other.

Results do raise the question, however, whether spectroscopic tests used are delicate enough for the purpose. Both theory and experiment indicate that much stronger bands occur farther in the infrared, which may be helped by spectrographs mounted in high-altitude balloons, rockets or artificial satellites.

On earth, the light from Mars is really a composite of three different spectra, containing absorption lines originating in the reversing layer of the Sun's atmosphere, Mars' atmosphere, and in the Earth's atmosphere. The wavelengths of the solar lines are accurately known.

For the much more difficult task of distinguishing lines due to Mars from those due to the earth, two methods have been in use.

One method is to observe Mars at "opposition" — when Mars, Earth, and Sun are most nearly in a straight line, with the Earth between the other two. Mars is then at its brightest. Because the distance between Mars and Earth is neither increasing nor decreasing, absorption lines originating in the atmosphere of Mars will not be separated by Doppler shift from those lines originating in the earth's atmosphere.

The second method is to observe Mars at some time before or after opposition, when the Doppler shift would clearly separate Martian and terrestrial lines. Then —if there is oxygen in the atmosphere of Mars—one might expect the oxygen lines caused by the Earth's atmosphere to have faint companions, separated by the amount of the Doppler shift.

The second method was used in the latest investigation. Spectrograms were obtained about seven weeks before opposition at Mauna Loa, and about six weeks after opposition at the Georgetown observatory. In the earlier spectrograms, the Doppler shift was 0.22 A (angstroms) toward the short wavelengths, and in the later ones, 0.25 A toward the longer wavelengths.

The new study of the Martian spectrum was undertaken in order to see what could be done with the newer aids to observation. These include better diffraction gratings and optical systems, faster photographic plates, and more accurate guiding mechanisms for prolonged photographic exposures.

The numbers of molecules of both gases are too small to be detected with the equipment used.

The spectrograph used in the present investigation could detect no H_2O bands beyond the one at 0.823 microns (1 micron=10,000A).

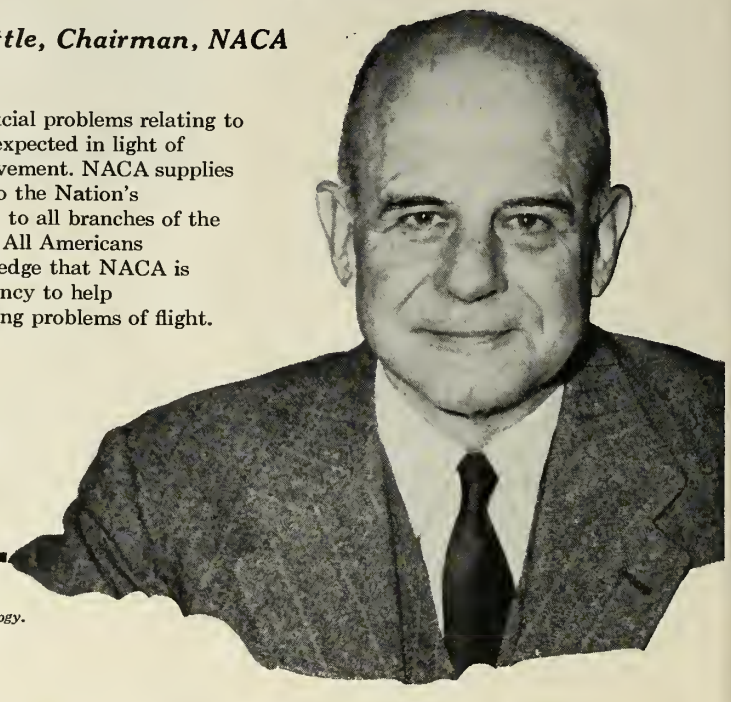
National Bureau of Standards Technical Report 2192 provides detailed data on the investigations.

A message for young physical scientists & engineers

from James H. Doolittle, Chairman, NACA

Future breakthroughs on crucial problems relating to aircraft and missiles can be expected in light of NACA's long record of achievement. NACA supplies advanced research findings to the Nation's aircraft and missile industry, to all branches of the military, and to the airlines. All Americans can be assured by the knowledge that NACA is working with a spirit of urgency to help solve the current most pressing problems of flight.

James H. Doolittle



James H. Doolittle, Chairman, NACA;
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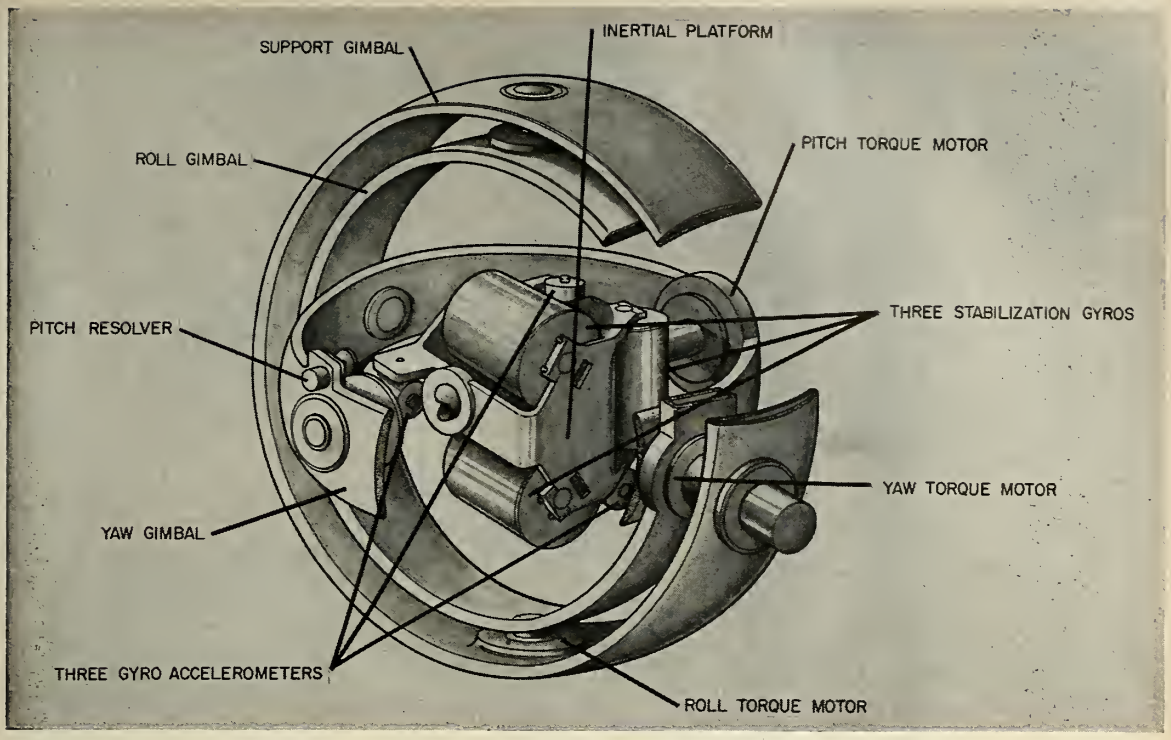

Outside-In Gimbaling Used In Thor

Optimum accuracy to be more important than weight considerations in guidance device

Ed. Note—The February issue of m/r (p 199) carried a description of the type of stabilized platform used on the Jupiter missile written by the Deputy Director for Guidance and Control, ABMA, F. K. Mueller. Because of the basic difference in concept between the Jupiter and Thor stabilized platforms, AC Spark Plug division of General Motors, manufacturers of the Thor guidance system, was invited to describe the Thor stabilized platform. Briefly, and to repeat from February, the Thor platform, like most units with unlimited travel in all three degrees of freedom (as in aircraft, land and sea applications), is gimbaled from the outside-in while the Jupiter platform departs from convention by gimbaling on a central core (from the inside out). Here, R. G. Brown, Thor Engineering Program Director for AC Spark Plug, describes the Thor platform and outlines some of the history preceding the choice of such a platform.

THE MOST IMPORTANT REQUIREMENTS placed upon the first inertial systems developed for manned long range bombers were those of unrestricted operational maneuverability and long flight times.

These two primary factors combined with the current development of gyros, accelerometers, and airborne electronic computer components, logically lead to the use of the external or outside-in gimbal system.

Pioneering work in development of inertial systems for long-range manned aircraft came out of the Instrumentation Laboratory of the Massachusetts Institute of Technology. Taking off from this study, AC Spark Plug engineers went to work on a basic system design that recognized the development status of floated gyros and analog computers, and employed these components to promote optimum accuracy rather than minimum weight.

Gyro drift characteristics were such that a true inertial or untorqued gyro reference platform was necessary. This, coupled with the requirement for unrestricted maneuverability, required external gimbaling, since this design approach readily provided wide angular freedom about more than a single axis.

Thus, the gimbal structure could perform a portion of the required coordination transformations. This mechanical analog computation was now possible with an accuracy that could not be matched by available airborne analog or digital computers.

Subsequent laboratory and manned aircraft flight testing showed that steady state deflections could be limited to less than a fraction of a minute by proper design of hollow box-section aluminum gimbals. During the course of the development program, design data was compiled on the stability of alignment of inertial sensor elements, the sensitivity of precision machining materials to thermo-cycling, and the vibration characteristics of the mechanical structure. This information formed a basis for de-

. . . gimbal system

sign in later development work on inertial systems for both air-breathing and ballistic missiles.

• **Ballistic programs**—The advent of Air Force-sponsored ballistic missile programs provided impetus to refining inertial sensor elements and mechanical packaging techniques. The large-sized gimbal systems used successfully in manned bombardment aircraft were known to be incapable of maintaining the necessary accuracy of inertial sensory alignment when exposed to high acceleration and vibration.

However, with the development of smaller gyros and accelerometers that had the required system performance capability, application of external gimbaling techniques in the design of missile guidance systems was again found to be practical.

It was natural in following development programs, to carry over as much of the experience gained in the use of externally gimbaled platforms as could be applied to ballistic missile systems. This was particularly true where abbreviated schedules reduced the time for development of a production prototype.

Thus, initial design efforts in the area of missile guidance revolved around the use of smaller gyros and accelerometers in conjunction with familiar and proven package designs.

The fact that external gimbaling could withstand high vibration and sustained acceleration with a conservative design margin was demonstrated by centrifuge vibration and rocket sled tests, as well as actual missile flight tests.

Where highly precise and stable mechanical alignment of the inertial sensing elements is essential, it has been found advantageous to use high density packaging techniques. This can best be achieved by applying the external gimbaling approach.

High density packaging is the practice of integrally mounting the stabilizing gyroscopes and acceleration sensing instruments in a tight cluster on a rigid platform. The use of precision machining and lightweight materials has made possible the design of a high density inertial instrument package, that is considered capable of meeting both weight and accuracy requirements.

Having attained the desired inertial package design, it is relatively easy to wrap two additional gimbals around it and provide additional degrees of freedom for preflight erection and in-flight stabilization. Use of newly engineered

. . . gimbal system

cross sections for these outer gimbals has resulted in a rugged gimbal system. Machining tolerances for the two outer gimbals need not be as stringent as for the inner rings, since they perform only a stabilization function and not a basic alignment reference function.

• **Gimbal unit details**—The accompanying sketch shows the essentials of a typical outside-in gimbal unit such as is presently being produced by AC for ballistic missile use.

The inertial instrument package includes three single-degree-of-freedom floated gyroscopes mounted directly to machined surfaces on the platform casting with their input axes mutually perpendicular.

The relative orientation of output and spin axes has no direct effect on system performance, so that orientation can lessen gyro drift effects and thus add to the accuracy of platform stabilization.

Also mounted directly to the platform casting are three gyro accelerometers oriented so that their input axes are mutually orthogonal and parallel to the stabilization gyro input axes.

The high density packaging approach minimizes the required number of separate parts by mounting the elements of the accelerometer drive servo directly to the single platform casting, rather than placing them on an intermediate support member.

Elimination of mounting supports and other parts not only achieves an increase in reliability, but also provides insurance against a shift in accelerometer alignment during field use. Missile applications where nut-and-bolt or screw-type mounting of critically aligned inertial members is employed are known to be prone to mechanical slippage.

In addition, such mounting methods often require highly skilled personnel using precision equipment to establish an accurate alignment between inertial elements.

Use of the inertial platform as an integral mount—easily accomplished with the external gimbaling approach—places the burden of alignment accuracy on basic machining tolerances, rather than on less easily controlled techniques of assembly.

• **Control simplification**—A by-product of high density packaging is simplification in thermal environmental control.

In ballistic missile applications, constant readiness requirements may dic-

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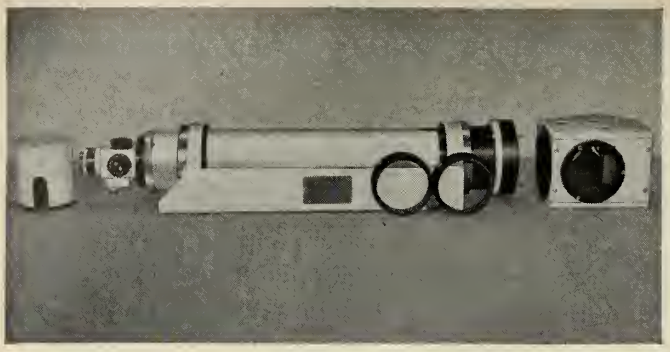

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. . . gimbal system

tate long-time stability of gyro and accelerometer characteristics. Stability of these inertial elements is extremely desirable from an operational standpoint: re-calibration and alignment checking of these units (often exacting procedures) are not necessary to achieve the missile flight objective.

Experience has shown that the required stability is most easily achieved by minimizing thermal cycling and gradients. The high density packaging offered by the outside-in approach generally reduces the volumetric requirement for thermal control. and hence simplifies establishment of a satisfactory temperature environment for the inertial sensing elements.

• **Design advantages**—Another advantage is that the gimbal rings which surround the inertial package provide a natural support frame for direct-drive torque motors.

The elimination of backlash and gearing inertia problems are advantages well known to designers of high resolution stabilization systems.

An objection to the use of the direct-drive motor has been the complexity and size of the associated power amplifier unit.

In recent years however, the reduction of load inertia attendant with miniaturization of the gimbal package, coupled with the development of high power transistors, has resulted in small and efficient amplifier units capable of powering the direct-drive mechanism.

In addition to affording a natural housing for the torquer, the wrap-around gimbal can be designed to support electromechanical resolvers and data synchros, potentiometers, transistorized amplifiers, and other components without appreciably increasing the overall size of the gimbal.

The accompanying drawing shows the pitch resolver used for the resolution of gyro error signals as typical of this type of component mounting.

While this article has dealt primarily with the advantages of external or outside-in gimbaling, there is much to be said of the inside-out approach, the gimbal-less approach, and other inertial sensor support techniques.

Each must be weighed on its own merits with a critical look at specific system requirements, status of development of primary inertial sensor units, in-house design and manufacturing experience, and the time allotted for development work and investigation of alternate approaches.

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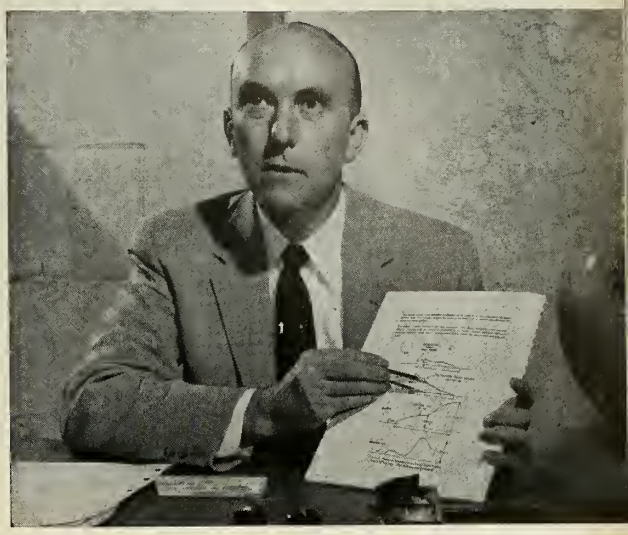

by Erica Cromley

PROGRESS has always leaned heavily on two types of people: the thinkers and the doers. Second to these are the teachers of the thinkers and doers—those who spark creative ideas in others and spur them into action. The world has had few who have combined all three. Robert P. Haviland is such a man.

As Advanced-Systems Planning Engineer—Satellites at General Electric's Missile and Ordnance Systems department, Haviland puts his rare talents to work on advanced satellite systems and on the creative potential of the young engineers which comes to fruition under his guidance. One company official said of him recently: "He has a unique way of laying out facts which tends to make the 'green' engineers creative."

Haviland, 44, has the type of mind that can get to the heart of a problem immediately. He has a vast store of knowledge in all the scientific and engineering disciplines surrounding missile work: electronics, electromechanics, propellants, instrumentation, testing, guidance, stress and human engineering factors.

There are any number of men who are more competent in each field, but few men can relate all fields as Haviland can.

His scope is vast. It is buttressed by a fantastic memory, constant study, an avid interest in his field and attention to details. His mind is always racing ahead. He is essentially a planner.

As early as 1946, he worked on extension of missile technology into the satellite field at the Bureau of Aeronautics. He then went to General Electric in 1947 as flight test engineer on such projects as *Hermes* and other extensions of the V-2.

On February 24, 1949, a modified V-2 *Bumper* reached a peak altitude of 242 miles. This was man's first toehold in space. Willey Ley, space lecturer, said in his book ROCKETS, MISSILES and SPACE TRAVEL: "Robert P. Haviland, who had been project engineer of the experiment, probably did more than any other single man to bring this shot about."

• **Christened**—References to Haviland as Mr. Missile Reliability go back to 1951 when he began his intensive study of missile failures. "I was greatly disturbed . . . every rocket I had worked on had at least one thing go wrong with it. For five years while I was flight-test planning engineer and systems engineer, I worked on reliability. I have finally evolved what I call a theory of reliability but I have not yet had time to verify it."

(This last refers to his report for GE, "Introduction to the Theory of Reliability"—an attempt to set forth basic principles which will determine whether a system will work before it is formally tested.)

Haviland's interest in space received its initial thrust during his college days at the Missouri School of Mines, Rolla, Mo., when much of his spare time was spent reading science fiction.

In 1939, when he received his BS in electrical engineering, he kept his feet on the ground as a geophysical engineer in field and development operations for a Texas Oil company.

During World War II, as a lieutenant commander in the Navy, Haviland served as project officer on radar beacons at radiation labs at MIT and the Bureau of Aeronautics. It was while with BuAer, when reports first came in on the V-2, that his interest in missiles was fired.

In 1945, after careful study of all the data available, he wrote a long memo to the Chief of BuAer telling him what could be done. This memo resulted in expansion of the bureau's rocket program which, even at that early date, included satellites.

Haviland early became concerned about America's status in the race to enter space—and the fact that the public still regarded space programs as "Buck Rogers stuff."

THE HAVILANDS practice the Cha-cha-cha, taught at a local dance class.

FAMILY PROJECTS. At home with the Haviland clan, a new world globe acquires a fresh paint job.

RADIO HAMS. The family tunes in regularly to Haviland's homemade radio set.

In September, 1957, a month before the launching of *Sputnik* I, Haviland warned, "We have grossly underestimated not only the potentialities of other countries, but also their rate of development and the impact of that development on the rest of the world.

Mere spending of money will not be enough. We need more intelligence and wisdom in order to determine the right way to spend money."

• **Achievements**—Haviland has written many papers which have received widespread acclaim, but four areas of his work stand out:

1945—A complete examination in the field of satellite vehicles for the Navy Department which led to a train of studies by various U.S. organizations.

1955—A paper on the "Application of the Satellite Vehicle" before the American Rocket Society, in which he critically examined the question of what will be done with space travel once it is achieved.

1957—Proposal of three large space stations as communications satellites for radio and TV in America, Europe, Asia; at the Congress of International Astronautical Federation in Barcelona, Spain.

Recently—The technical study of the communications proposal.

Haviland, the man, feels keenly the responsibilities of Haviland, the scientist. Basically shy and introverted, he is given to meditation about man's role in the universe and whether he will fulfill it. "We have to find out why mankind is here or we are not going to be here," he said recently. "Space offers man an alternative to destruction to satisfy his drive to conquer. If we direct our energies up there, we won't be destroying each other down here."

He feels strongly about the dignity of the individual. "Me-too-ism is the worst danger to our American civilization and right now, it is a very popular concept. We have got to stop looking down on people because they're different. Creativity requires an atmosphere conducive to inquiry, independence and analysis."

However, Haviland is a proponent of moderation ("my byword," he says), and is concerned that we don't swing too far the other way. "Until recently we have not emphasized science enough. Now the danger is that we may emphasize it to the exclusion of other things just as important."

He feels that young people should be taught to express themselves adequately; while there should be increased emphasis on science there should be similar emphasis on English. "You can give young people a tremendous amount of scientific background, but, if they do get creative ideas and cannot adequately communicate them to other people, they are useless."

• **No chips off the block**—His three children have been brought up with emphasis on family intercommunication, but so far there are no signs of following pa's professional footsteps. They are happy, imaginative youngsters.

Kay, 17, a senior in high school, wants to be a librarian. Jean, 15, a high school sophomore, has her sights set on a nursing career. Jon Robert, 12, is no further out of the atmosphere than airplanes, his hobby; and boy scouting, his avocation.

Haviland met Opal, his brunette wife, during his early college years at Central Wesleyan College at Warrenton, Mo. They were both working their way through college—she as secretary to the college president; he as a movie projectionist in a local theatre.

The Havilands' contemporary house in Radnor, Pa., just outside Philadelphia, is their 23rd dwelling place in 18 years.

The Havilands don't get as much time together as they would like because of the rugged traveling schedule that goes with a scientist's job.

Family projects when they are together include: working the ham radio set that Haviland put together; building furniture (23 pieces in the last few years, including a space-flight design mosaic coffee table); painting a three-dimensional relief model of the earth; and outdoor cookery on the terrace.

Last year the Havilands took a dance course which they try to put into practice at least once a month. No community joiner, Haviland's one exception is a local swim club where he exercises.

He is active, however, in professional organizations: American Institute of Electrical Engineers, American Rocket Society, Franklin Institute and British Interplanetary Society. He is also on m/r's advisory board. Just recently he was elected to membership

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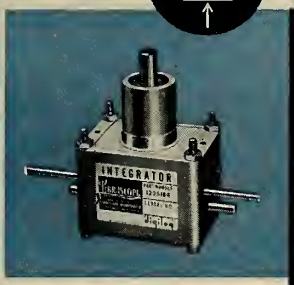

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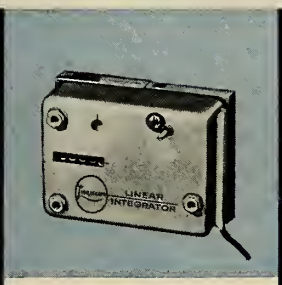

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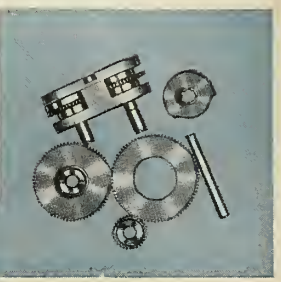

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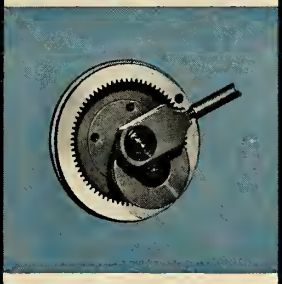

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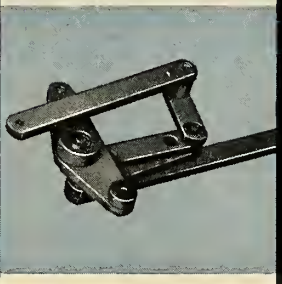

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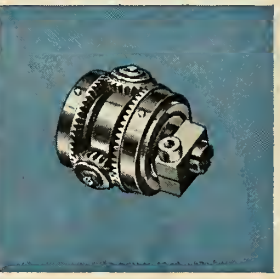

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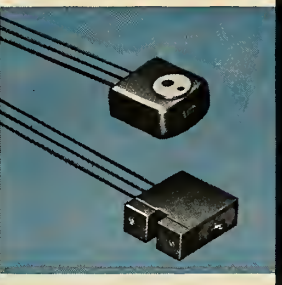

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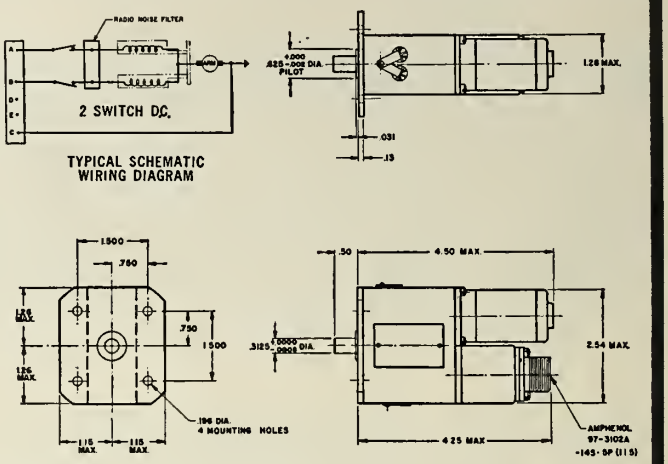

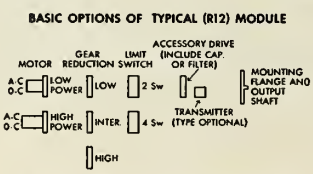

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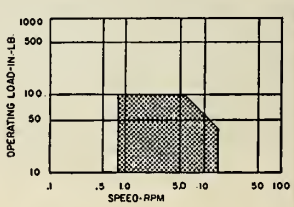

Area under curve represents performance range available with standard components. Performances beyond these limits may be achieved by using special components.

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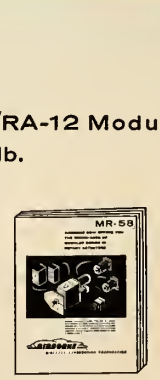

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. . . profile

in the national electrical engineering honor society, Eta Kappa Nu.

• **Bookworm**—Young Haviland grew up on a farm in Patmus, Ohio, but his mind was not on farm chores. "When it was milking time they could never find me. I was usually off somewhere with a book." Kid games and horseplay never interested him. Haviland sopped up information from every science and adventure book he could get his hands on. He was obsessed with the "why" of things. At age eight, he took the alarm clock apart to find out what made it tick—but couldn't get it back together again.

A sound tanning might have turned the budding scientist to safer juvenile pursuits and the world would have been the poorer. Instead, father Haviland expressed "mild annoyance" and the subject was dropped.

His father did, however, insist he learn a trade, and saw to it that Haviland absorbed the fundamentals of carpentry—a skill he now keeps sharpened on family furniture building projects.

• **Future pursuits**—Haviland describes his present position as one without assignment. "My job is to think about the future." Future thoughts now are on commercial uses of satellites. Of these, Haviland is concentrating on three: communications (for international TV reception), meteorological (more accurate weather forecasting) and geodetic (more accurate mapping of the earth).

The space scientist predicts that within 10 to 15 years Americans will be tuning in their TV channels to Buenos Aires and London as nonchalantly as they flip their set to the local stations today.

These and other space vehicles are the subjects of Haviland's thoughts as he postulates the problems involved with their achievement.

Haviland's working day is spent in a small white office on the third floor of GE's plant at 3198 Chestnut St., Philadelphia. But his mind is 4,000 miles up in space—and five to ten years ahead of the engineers who will one day convert these thoughts to the instruments by which man will break loose from earth and fly out into space.

• **Point of no return**—An admirer of Haviland recently asked him, if, since his working day took him so far out into space, he had any difficulty coming back to earth at quitting time.

"Who comes back?" Haviland replied.

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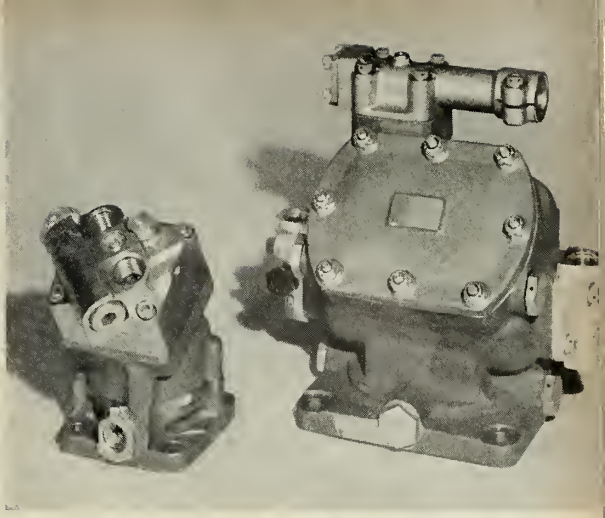

FIG. 1. Comparison between standard and miniaturized variable-delivery pumps of same output. New design saves 2.3 lbs.

by William Patterson*

EVERY REDUCTION in the weight and size of a missile or rocket component makes it a little easier for the vehicle to penetrate the earth's atmosphere.

At Vickers, Inc., a significant contribution to hydraulic component weight and size reduction was made when recent tests were completed on a new variable delivery pump with a 100% increase in power-to-weight ratio. With today's missiles and rockets carrying as many as 10,000 separate assemblies, miniaturization of components is an important phase of development.

• **Figure 1** shows the comparison between a standard size variable pump and the miniaturized version capable of the same output. This miniaturization of the variable delivery pump represents a 48% weight reduction and 70% smaller envelope.

This means a savings of approximately 2.3 pounds without sacrificing volumetric or overall pump efficiency. Reliability and response characteristics equal or exceed those of the standard variable hydraulic pumps now in use on aircraft and missile applications.

These facts and figures become particularly impressive when it is considered that for every added pound of component weight, a missile's gross weight is increased 30 to 50 pounds. Since liquid fueled turbines have a high specific fuel consumption, and in many cases are used to drive hydraulic auxiliary power units, high pump efficiency and lower weight can be translated into less fuel carried or longer burning time.

If the missile hydraulic accessory power unit is battery powered, the same

*Senior Staff Engineer
Aero Hydraulics Division, Vickers Incorporated

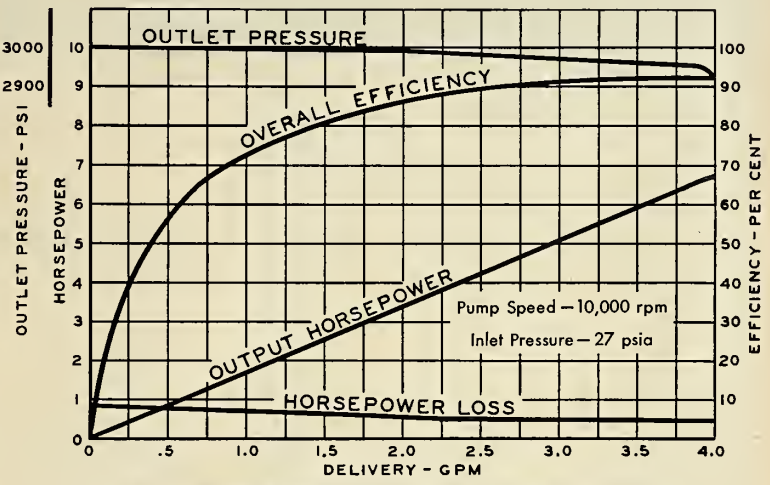

FIG. 2. Pump efficiency is shown over entire flow range.

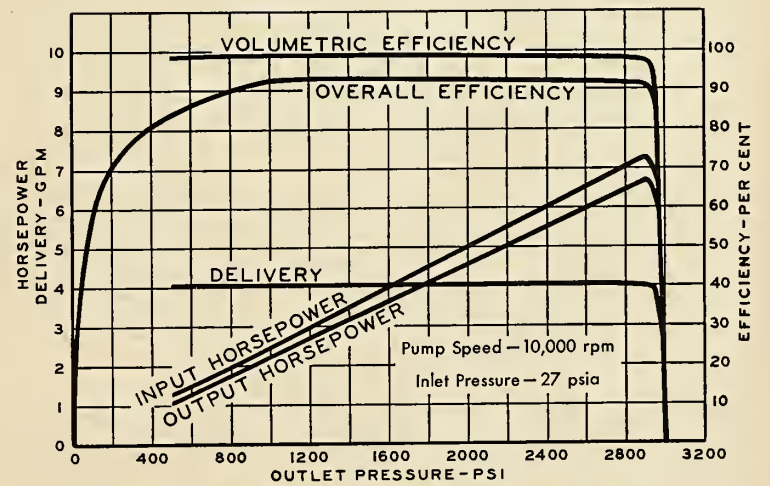

FIG. 3. Pump efficiency is charted over pressure range.

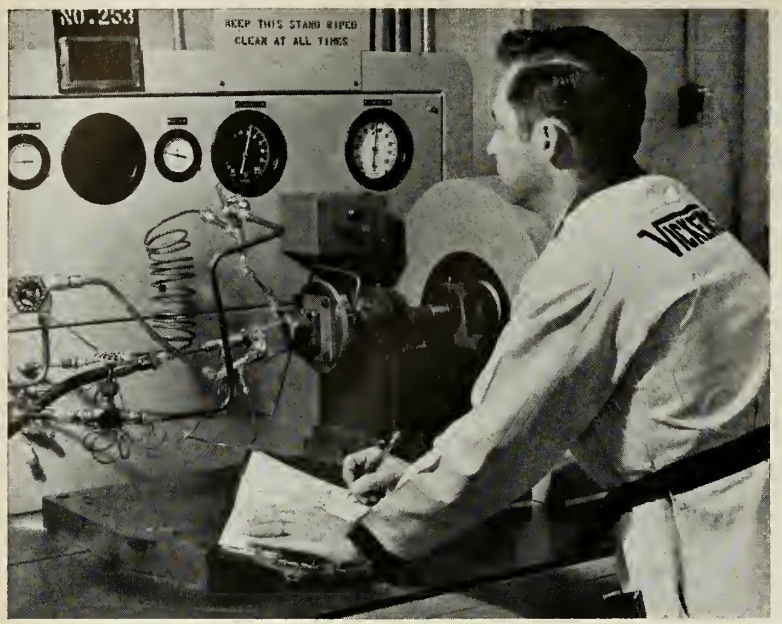

FIG. 4. Laboratory setup for endurance run of pump.

advantages apply in terms of lower electric current drain, less battery weight and longer discharge time.

• **Variable pump**—The variable displacement pump compares favorably in size with that of a standard constant displacement pump and means that variable delivery output is available from a constant displacement size package.

Development of the miniaturized variable pump actually covers several years and is the result of continuous research and engineering efforts to improve existing components.

Much of this product improvement effort was directed toward achieving optimum valve port location and shape to achieve the ultimate in pumping efficiency. Also, changing the angular position of the valve plate inlet and outlet ports with respect to piston position would vary the fluid volume delivered by the pump.

This design principle indicated that substantially fewer parts would be required and that a marked reduction in overall weight and size would result, if the reduced design would not sacrifice efficiency.

The critical need for high efficiency, low weight and size hydraulic components for missile applications prompted a concentrated attack on these problems by the company's engineering and research facilities of prime importance to the researchers was no loss of power in favor of weight.

The miniature variable displacement pump is a direct descendant of the axial piston fixed displacement design that has millions of hours of proven service dependability. The similarity extends to the rotating group of the new pump that has the same proven design for 3000 psi operation, but incorporates new features that permit much higher rotative speeds and shorter overall length.

The unit is rated at 8000 to 12,000 rpm for 1000 hour life applications; 12,000 to 18,000 rpm for missile applications; and up to 24,000 rpm for transient, overspeed and intermittent duty.

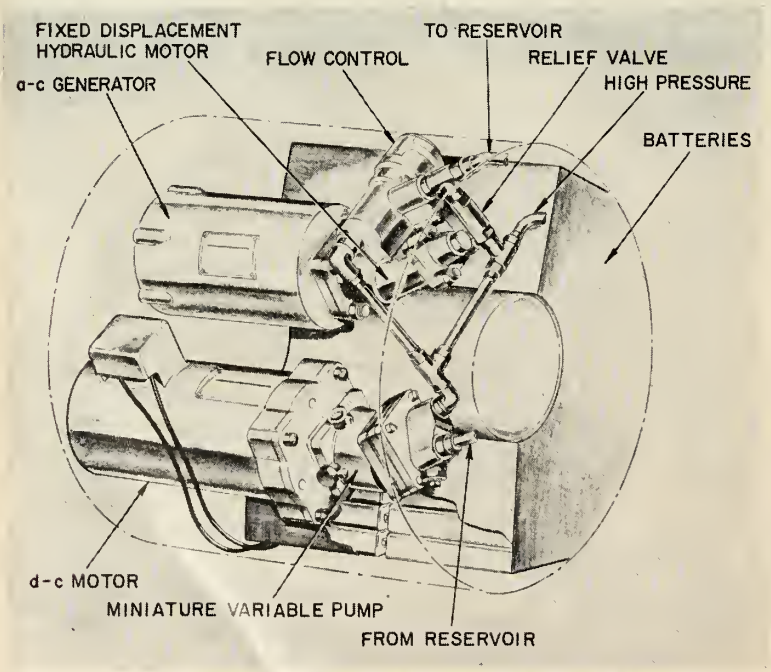

FIG. 5. Proposed auxiliary power system using new pump.

• **Characteristics**—Together with inherent reliability through simple operation of fewer moving parts, the pump possesses extremely high power-to-weight ratio (7.2 hp/lb) at 24,000 rpm and an equally impressive power-to-volume ratio (0.86 hp/cu in.) for the consideration of missile makers.

While these ratios provide an excellent means of comparing power generating and conversion devices, the real criteria for measuring pump performance is volumetric and overall efficiency.

Because variable delivery pumps are selected to conserve energy at power levels of less than full demand, pump efficiency at partial flow conditions is the real test of variable delivery pump performance.

Figure 2 is a curve that shows the pump's efficiency over the entire flow range. Note especially the high efficiencies in the low flow range as shown in the chart.

Figure 3 shows that at full delivery, volumetric efficiency remains at the 96 to 98% level over a pressure range of 500 to 3000 psi.

High efficiencies across the entire

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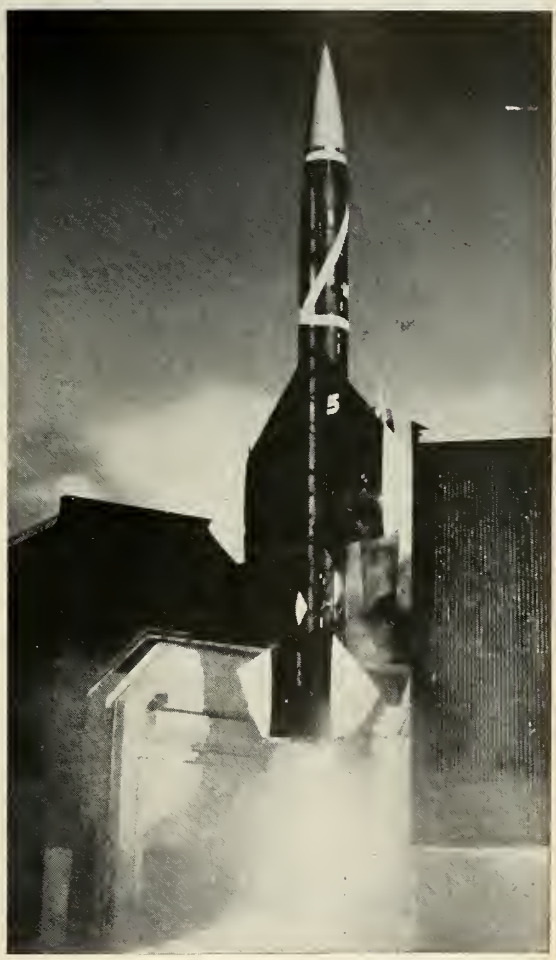

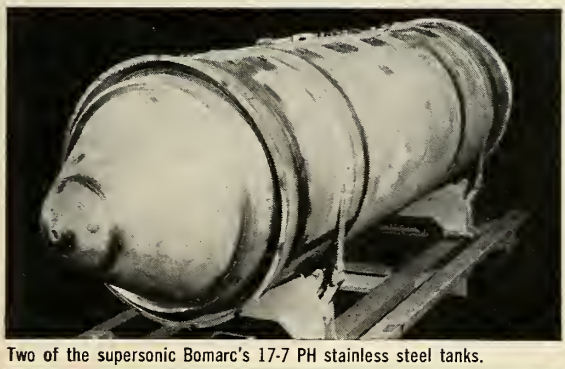

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FIG. 6. Typical motor-pump combination used in a surface-to-air flight control system.

flow range, and especially at lower flows, are significant with respect to the amount of heat rejected to the hydraulic system. Since many missiles do not utilize hydraulic system cooling, the higher pump efficiency will result in lower final systems temperatures.

Lower temperatures contribute materially to improved reliability of systems components. This heat rejection advantage is significant with respect to prime mover horsepower, reduced fuel load or longer burning time.

Missiles go through a growth period whereby second and third generation models have greater range, speed and accuracy, A hydraulic system which performed satisfactorily on a first generation missile may be marginal or inadequate to meet the operational requirements of later missiles. The heat rejection savings of the miniature variable pump promises to save a complete hydraulic system redesign on later models.

• **Rapid response** is a critical factor in missile guidance systems. The miniaturized variable pump is capable of full flow to zero flow response in 0.02 seconds and zero flow to full flow response in 0.04 seconds. The pump's proven stability immediately after a change in flow and the complete absence of pressure oscillation will provide smooth flight control operation and increased hydraulic line and fitting service reliability.

The development test program for the miniature pump involved over 2,500 hours of testing in Vickers component development laboratories.

One endurance run (shown in Figure 4) on the variable control mechanism required 1074 test hours to produce 1,000,000 cycles under full flow to zero flow delivery conditions approximately every four seconds. This and other endurance tests definitely proved the durability of the design and estab-

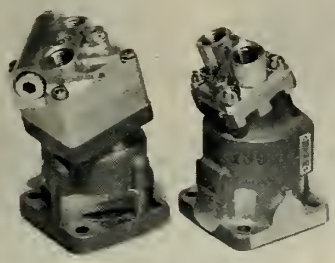

FIG. 7. Comparison of a variable displacement pump (left) with a standard constant displacement pump (right).

lished a design life for the new pump of 750 hours at 8000 rpm, 375 hours at 16,000 rpm and 50 hours at 24,000 rpm.

Currently, 24,000 rpm is considered a transient or overspeed condition, but the 50-hour design life for steady state operation appears to be attainable.

To date, all applications of the miniaturized variable pump have been for MIL-0-5606 fluid in the operating temperature range of −65° to +275°F. Other fluids can be accommodated by changing only the elastromeric seals.

• **The practical application** of the variable valving principle has resulted in a hydraulic power source of extremely low weight and small size, high efficiency, and rapid response with equal or better reliability than its predecessor.

This ideal combination of features meets the present urgent requirements of missile hydraulic systems. One such requirement is a missile motorpump to power the flight controls for a surface-to-air missile. It supplies 1.8 gpm at 7300 rpm and weighs only 9.3 lbs.

Figure 5 shows the miniature variable pump used in a proposed auxiliary power system for a missile now under development. The requirements for this power system are to provide 1 kva of 400 cycle AC electrical power and a hydraulic flow of 4.74 gpm for a duration of 2.5 minutes.

The system is battery powered and in addition to the miniature variable pump, a fixed displacement constant speed motor, a 1 kva alternator, and associated circuitry and controls comprise the assembly.

Fig. 6 shows a typical motor-pump combination used in a surface-to-air flight control system.

Fig. 7 compares a variable displacement pump (left) with a standard constant displacement pump (right) and illustrates the packaging economy achieved with the new unit.

space medicine

by Hubertus Strughold, M.D., Ph.D.

Spotlighting the growing importance of space medicine were two recent meetings—one a classified session—that brought specialists from all parts of the U.S. to listen, discuss and learn.

The public meeting was a symposium on "Simulated Atmospheres and Foreign Environments in Space Operations", conducted during the annual Washington meeting of the Aero Medical Society. Seven papers (to be published subsequently in the Journal of Aviation Medicine) gave an overall picture of human experience in such projects as Man High, Stratolab; and in submarines, space cabin simulators and pressure suits.

At this session, Dr. Siegfried Gerathewohl, of the Department of Space Medicine, School of Aviation Medicine, Randolph AFB, Texas, received the Tuttle Award for his studies on the psychophysiology of weightlessness, produced in jet airplanes. The studies were based on more than 2,000 parabolic flight maneuvers flown by Maj. Herbert D. Stallings.

The "classified" meeting—very well attended, by the way—was a two-day affair conducted by the National Advisory Committee for Aeronautics, at Cleveland. Chairman was S. P. Johnston of New York, director of IAS.

Further details have become available on the paper, "The Star Ecospheres Within a Radius of 17 Light Years from the Sun," presented by Prof. Jan Gadomski, director of the Astronomical Observatory of the University of Warsaw, Poland. This paper was on the program of last year's Barcelona meeting of the International Astronautical Federation.

The ecosphere, as described by Prof. Gadomski at the Rome meeting of the Federation in 1956, represents a zone covering a certain distance range around the sun in which the radiation intensities and their effects upon the planetary atmospheres are such that life on planets found in this zone is conceivable. In our solar system this zone extends approximately from Venus to Mars.

Prof. Gadomski applied this concept to other stars and came to the conclusion that of the 59 stars found in this zone, about 16 might have the properties of being surrounded by an ecosphere. He concentrated in his mathematical calculations upon their extensions and placed the sun, in this respect, in fifth place.

Sirius A possesses the largest ecosphere, followed by Altair, Prokyon, and Alpha Centauri B. The next star after the sun is Alpha Centauri A. This paper represents an excellent example of the importance of the borderland between Astronomy and Biology.

Red War Sputniks in the Works?

by Dr. Raymond L. Garthoff

AFTER THE RUSSIANS sent their first man-made moon skyward, speculation rose on how far they had progressed on a military satellite. Some Russian experts in this country claim the time for achievement of a USSR war moon is not far off.

Soviet writings on the subject have mentioned several destructive roles for such a vehicle in the event of war, from its obvious use as a reconnaissance vehicle, jamming station or rocket launcher to an Orson Wellsian instrument of annihiliation—a platform for a giant space mirror which could burn cities, cause typhoons and detonate munitions factories.

Current Russian silence on even the possibility of a military satellite suggests the existence of considerable Soviet sensitivity over the question.

It is clear from the few apparent slips in Soviet secrecy that the Soviets are well aware of the military potential of a satellite and are pushing such a program with vigor.

The military mission for an artificial earth-satellite most frequently mentioned in the West is ultrahigh-altitude strategic reconnaissance. This has been briefly mentioned in a technical article on satellites by Prof. Yuri Pobedonostov in the official Soviet Air Force journal VESTNIK FLOTA (Herald of the Air Fleet) in September, 1955.

This reference to a reconnaissance satellite was by no means the first. In a scientific journal in Leningrad in 1926, the now prominent scientist and military technologist, V. P. Glushko, had quoted an even earlier article by German Prof. G. Oberth as stating that "one can observe and photograph inaccessible countries" by means of a giant mirror mounted on a satellite vehicle.

In December 1947, NEW TIMES carried an article by M. Rubinstein ridiculing alleged American use of "Hitlerite ideas" and in particular the "fantastic" idea of a reconnaissance satellite. Again, in November 1949 in NEW TIMES, G. Tarle referred to "the madman Forrestal's idea of an earth satellite" as "an instrument of blackmail."

In July 1952, the Soviet Army newspaper RED STAR ran an article in which the late Secretary of Defense Forrestal, Dr. Werner von Braun, and Dr. Joseph Kaplan were reviled for having written about the possible military uses of satellite vehicles to "peep into other countries as through a keyhole."

Finally, just before *Sputnik* was launched last October, Maj. Gen. Pokrovsky wrote that satellites have "military significance. From them one can conduct observation of the enemy's territory." With these few exceptions, Soviet published sources are not known to have mentioned satellite reconnaissance missions.

Now, by placing their first satellite in an orbit which swept all of North America, the Soviets established a precedent which will permit reconnaissance satellites to be similarly orbited without permitting effective objections. We, on the other hand, had planned our satellite orbits to avoid the USSR in order not to alarm them or give them grounds for propaganda.

There have been reports that even the first Soviet satellite had infrared devices to map the United States for ICBM targeting purposes. Dr. Alexander Sherban, a Soviet scientist visiting in Yugoslavia last October, confirmed that some such operation was being conducted by the initial *Sputnik*.

The second possible military use of a satellite would be bombardment of targets on the earth by rockets

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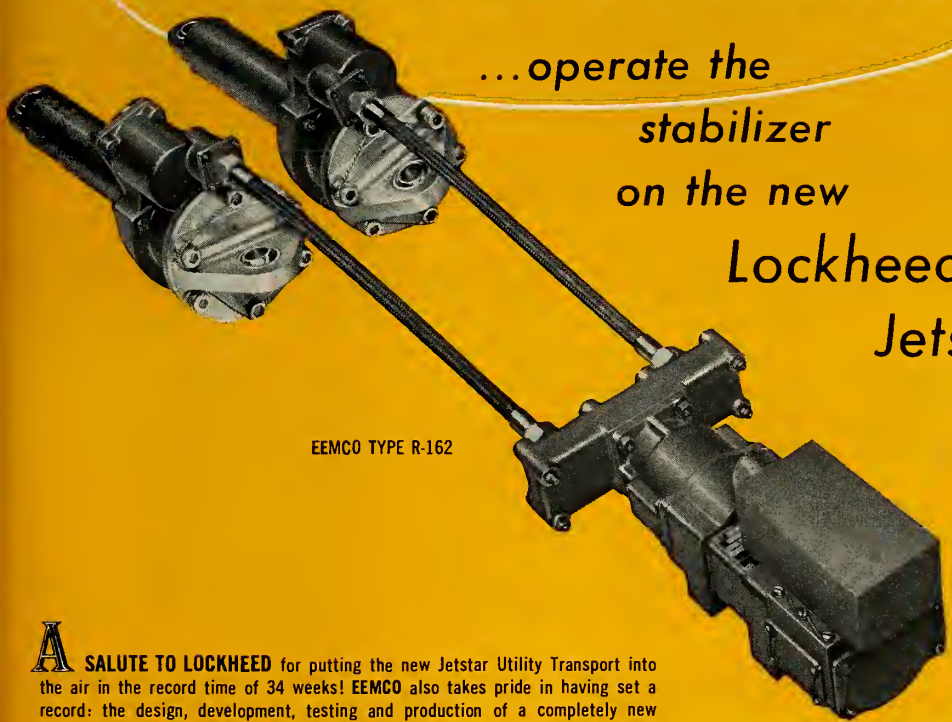

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launched from the vehicle. Again, there have been but a few references to this possibility in Soviet publications. The first was the following sentence in a book title THE STRUGGLE FOR SPEED, by the well-known Soviet engineer Boris Liapunov, published in 1952: "From a satellite one can control almost the entire planet, firing rockets at any point on the earth."

It has been charged that America was interested in using a satellite vehicle for atomic bombardment. The previously cited 1952 RED STAR article also attacked von Braun for having said such a vehicle could be used for launching missiles with atomic warheads. "Being obsessed with megalomania," said RED STAR, "they dream of the possibilities of launching from this artificial moon radar-guided missiles with atomic warheads 'against any point on the surface of the earth with fatal accuracy.' This is what the Yankees are thinking about as they dreamily look up at the shining stars."

The next reference appeared in 1954 NEW TIMES article called "Interplanetary Bunk" which said: "This is not the first time the United States is hearing ravings about 'artificial satellites' and interplanetary ships and stations from which atom bombs could be showered on parts of our planet to which Wall Street has taken a dislike. It will be recalled that a former U.S. Secretary of Defense, Forrestal, frantically urged the building of an interplanetary war base without delay."

In 1956, a Soviet military theoretician, of total war recommend thinking in advance about the employment of artificial satellites of the earth for atomic bombardment . . . " And in September, 1957, Maj. Gen. Pokrovsky referred to foreign discussions of possible military uses of a satellite as including "delivery of atomic and hydrogen bombs."

Finally, in the only case of direct Soviet admission of interest, Gen. Pokrovsky also stated shortly before *Sputnik* was launched: "The question is raised (sic) on the utilization of artificial earth satellites for delivery of atomic bombs prepared for such launching."

A third possible military use of a satellite vehicle again involves the mirror idea—the mounting on a satellite vehicle of a giant mirror to reflect and concentrate the sun's rays. Gluskko's 1926 article said: "With its aid, one can detonate munitions factories, provoke whirlwinds and storms, annihilate marching troops, burn cities, and in general wreak colossal damage."

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Linearity: ±0.75%
Stability: ±1%
Input Ranges: 0 to +3, 0 to −3, 0 to +5, 0 to −5, ±2.5 VDC and ±1.5V for ±7.5% or ±15% deviation
Input Resistance: 250 K, ±5%
Output Impedance: 100 kilohms
Output Voltage: 4.0 Volts rms, open circuit
Typical Operation: Supply: 24 VDC @ 12.5 ma. Bias: 30 VDC @ 1 ma.
Size: 3.125" x 1.565" x 3.85"
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with Silicon Transistors

These oscillators are used with variable resistance type pickups such as strain gages, thermistors, etc. with bridge resistance values of 120 or 350 ohms. The units operate over a temperature range from 0°C to +85°C and will withstand 25G vibration to 2000 cps. They are available for standard IRIG bands from 1.7 kc through 14.5 kc inclusive. Other specifications are:

Linearity: ±1.0% of bandwidth
Stability: ±2.0% of bandwidth
Input Ranges: 120 ohm or 350 ohm resistance bridge. ΔR/R from 0.25% to 1.0%.
Output Impedance: 100 kilohms
Output Voltage: 3.0V rms open circuit
Typical Operation: Supply: 24 VDC @ 12.5 ma.
Size: 3.125" x 1.565" x 3.85"
Weight: 0.8 lbs.

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Input Voltages: 70 Volts AC 360 cps to 4400 cps @ 140 and 40 MA from separate sources, or two separate 50 Volt DC sources.
Regulation: 30 Volt regulator: ±0.25%
24 Volt regulator: ±1.0%
Ripple: 30 Volt regulator: 5 Millivolts maximum if driven from a sine wave source. 24 Volt regulator: 18 millivolts maximum if driven from a sine wave source.
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Weight: 0.8 lbs.

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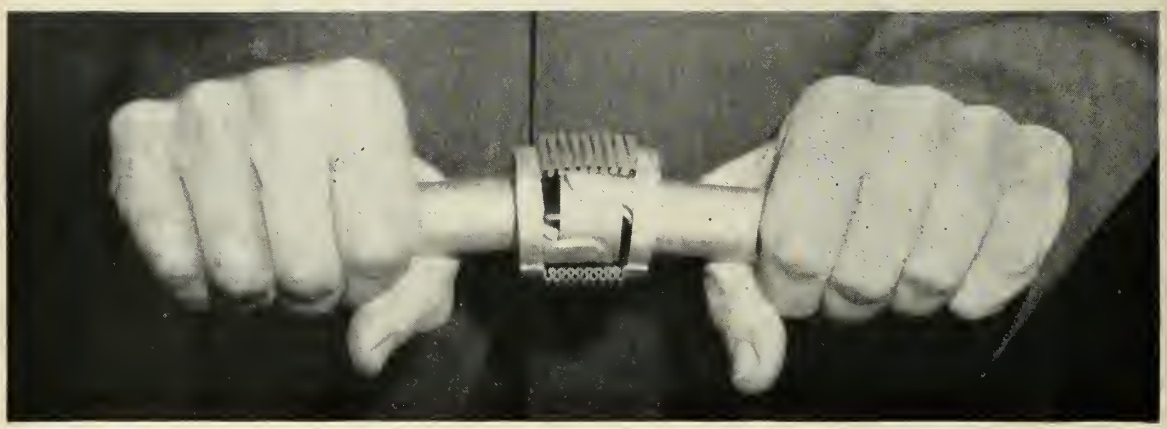
NEWS FROM FLEXONICS

DUCTING AND COMPONENTS ENGINEERING BRIEFS

One of a series of reports to help you make more effective use of Flexon products.

THE FLEXON GIMBAL JOINT

A new approach to absorption of ducting motion in any plane



Flexon Gimbal Joint cutaway to show how it permits motion in any plane yet is self restrained.

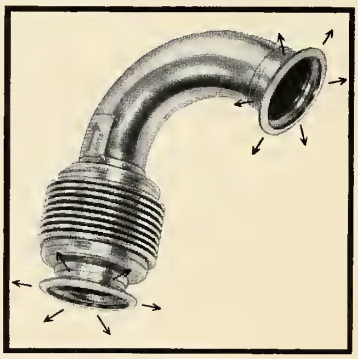
To answer a critical motion absorption problem in the most advanced jet aircraft and missiles, Flexonics engineers reached back over 500 years. They took the gimbal principle—the same one used in the compasses of Columbus, Magellan, da Gama, et al—and applied it to a flexible connector. The result is the Flexon Gimbal Joint.

Here is a joint designed especially for the supersonic space age. Its design recognizes the problems of thermal expansion, installation misalignment, air frame deflection and high end loads which are so critical in modern jet aircraft and in missiles and rockets.

The simple, efficient design provides a combination of advantages available in no other type of flexible connector:

1. Completely self-restrained.
2. Low loads for deflection.
3. Reduced pressure drop (liners incorporated).
4. Reduced system weight—heavy anchors are eliminated—simple line supports are the only requirement.
5. Minimum envelope.
6. Maximum fatigue life verified by comprehensive laboratory tests.

Significant, too, is the fact that the Flexon Gimbal Joint will take motion in any plane. Joints taking motion up to 7° have been manufactured and are in service. The units are made in high strength corrosion resistant alloys to meet specific requirements. Sizes range from 1″ through 4″.



The Flexon Gimbal Joint can be used to join a variety of tubing shapes to make a wide range of connector types.

Engineering Assistance on Ducting Problems

The Flexon Gimbal Joint is only one of many Flexonics developments for the advancement of the science of aircraft and missile plumbing. Other products include metal, synthetic and plastic hose, flexible ducts, liquid oxygen lines, pinned elbows, high pressure ducting and thin wall tubing.

Out of this background has come unmatched experience proved in many of the nation's most advanced aircraft, rocket and missile programs. This experience is available to help you in the solution of your most advanced design problems. Put it to work!

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For help on specific problems send an outline of your requirements. Flexonics Application Engineers will be pleased to make recommendations.

AERONAUTICAL DIVISION
A-38

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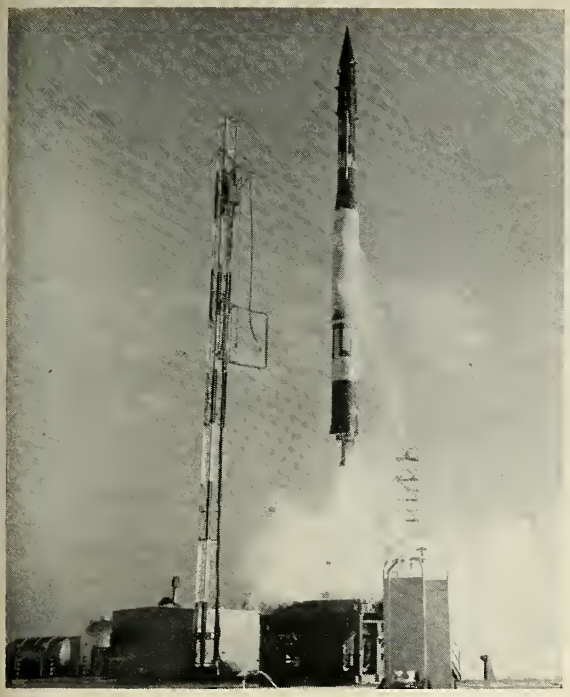
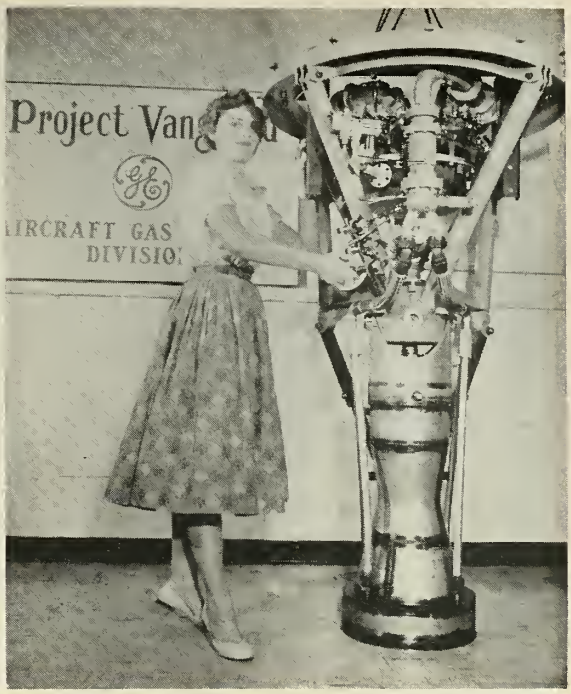




General Electric

Power in a peanut:

General Electric's X-405 Vanguard Engine -- where it is and how it got there

by Louis Michelson*

TO ACHIEVE its specified orbit, the U.S. IGY earth satellite, launched by the *Vanguard* rocket, must attain an altitude of 300 miles and a velocity of 18,000 mph.

These requirements demand tremendous power, an examination of the *Vanguard* weight breakdown shows. Of the initial weight of more than eleven tons at launch, some nine tons are fuel and oxidizer.

Power is provided in the *Vanguard* vehicle by three stages, each driven by a separate engine. The first stage engine, built by General Electric Corp., lifts the vehicle to about 40 miles and accelerates it to 3,000 mph.

Aerojet-General Corp. supplies the second stage engine, which raises the vehicle to the satellite launch altitude of 300 miles, and accelerates it to 9,000 mph. The final velocity increment will be supplied by a solid rocket engine. Allegheny Ballistics Laboratory and Grand Central Rocket Corp. are building units for this mission.

On launching, the *Vanguard* is powered by the GE X405 engine. Providing 27,000 pounds thrust for about 140 seconds, the engine burns liquid oxygen and kerosene in its single, regeneratively-cooled thrust chamber. The propellants are supplied at high pressure to the thrust chamber by twin centrifugal pumps driven by a single impulse turbine. Power to turn the turbine is supplied by the decomposition products of concentrated hydrogen peroxide. The thrust chamber is gimballed to provide thrust vector control.

• **Birthplace**—The X405 is being built at GE's Evendale plant at Cincinnati. Here, the company has more than 6 million sq. ft. of floor space and a total investment of over $100 million.

Besides manufacturing and assembly capabilities for aircraft gas turbines and rocket engines, complete laboratory and testing facilities are maintained. A computation center, housing IBM 701 and 704 computers, provides a central source of data reduction.

Rocket engines, such as the X405, are tested at the Malta Test Station, near Schenectady, N.Y., operated for the Air Force by GE. Some 30 sites for conducting component and systems tests are maintained, along with complete administration, shop and warehouse facilities. Hydraulic, chemical and propellant laboratories provide services to the rocket engine testing activities.

The test station was constructed 12 years ago for Army Ordnance and it has been modernized continuously.

It was here that GE conducted its rocket engine and missile systems tests for the *Hermes* and *Bumper* projects. A *Bumper* missile, launched in 1949, recently held the published altitude and velocity record.

• **Evolution**—During the *Hermes* work, GE built and tested the X400 engine, forerunner of the X405. The

*Manager, Rocket Engine Section, General Electric Corp.

X400 was overshadowed by X405, which produces more thrust and burns longer. In addition, the X405 chamber is gimballed and a hydraulic pump drive was added to the turbopump assembly equipment.

The X405 is a liquid bi-propellant engine. Liquid oxygen and kerosene are stored in the large first stage tanks, built by The Martin Co. These propellants are supplied, under a small positive head provided by helium gas pressurization, to the twin centrifugal pumps. The pumps increase the fluid pressures tremendously, providing high-pressure flow to the thrust chamber. Both pumps and the impulse turbine are combined in a single turbopump assembly mounted on pads in the main thrust structure assembly.

• **Fuel Flow**—Power to turn the impulse turbine is provided by decomposition products of hydrogen peroxide. The hydrogen peroxide is stored in a missile tank and forced to the gas generator at high-pressure by helium.

Both propellant pumps and a hydraulic power pump are driven through gears coupled to the main turbine shaft.

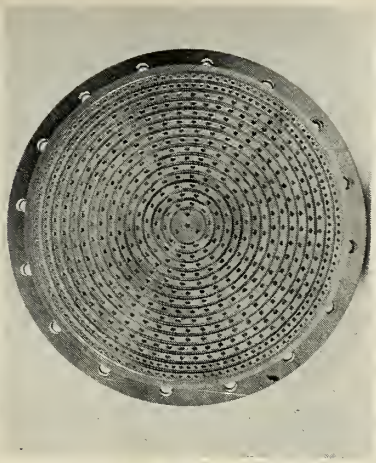
From the pumps, the main propellants flow to the thrust chamber, through a propellant control valve, through flexible lines, and into the coolant jacket of the thrust chamber.

Following this jacket, the fuel spirals upward through helical passages, through the injector, and into the combustion chamber. This provides a coolant for the combustion chamber and nozzle, regeneratively cooling the inner liner and permitting more than two minute operational cycle. The oxidizer flows from the pump through a control valve, a flexible coupling, and then directly into the oxidizer inlet of the injector.

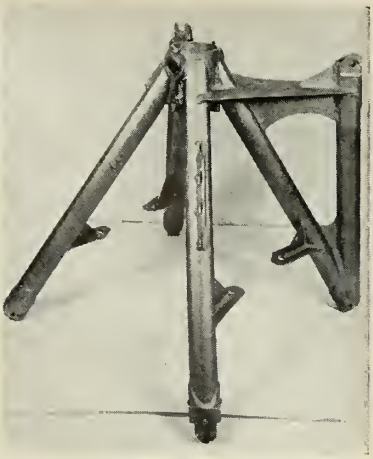
In the GE injector, distribution of oxygen is distributed from a domed area that covers the entire backplate, down through spaced slots to concentric grooves. The oxygen flows along these grooves and supplies the injector holes.

Fuel enters the injector directly from the coolant jacket, passes through radial holes and again enters the concentric grooves through a series of slots or holes.

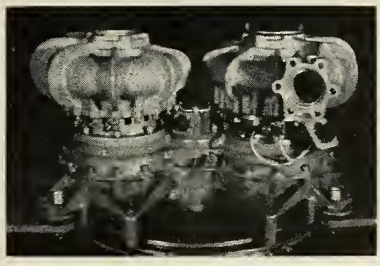
The radial fuel holes are so spaced as to pass between the axial oxygen feed slots. Particular care must be taken in design and manufacture of backplates to prevent cross-leakage within the backplate, because this almost without exception results in cata-



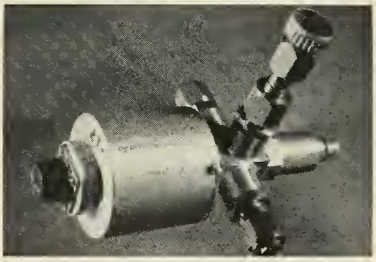
Injector head



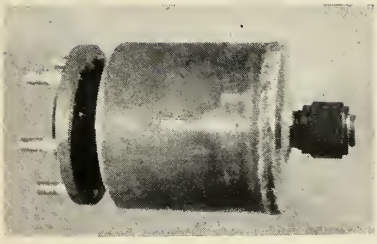
Thrust structure



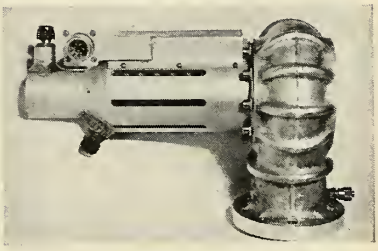
Turbopump assembly



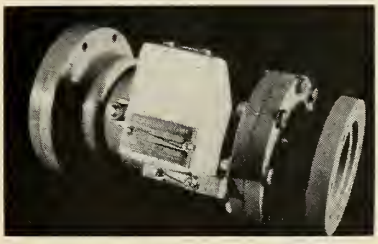
H_2O_2 control valve



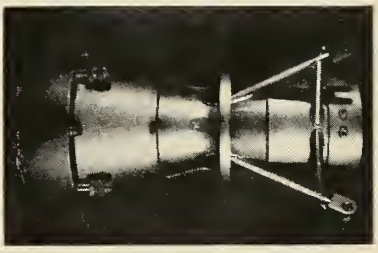
Turbine drive



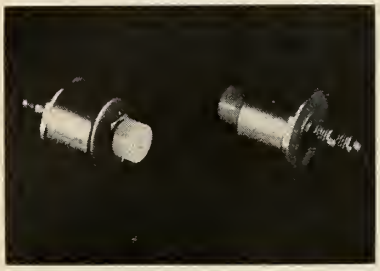
Oxidizer valve



Fuel valve



Thrust chamber assembly



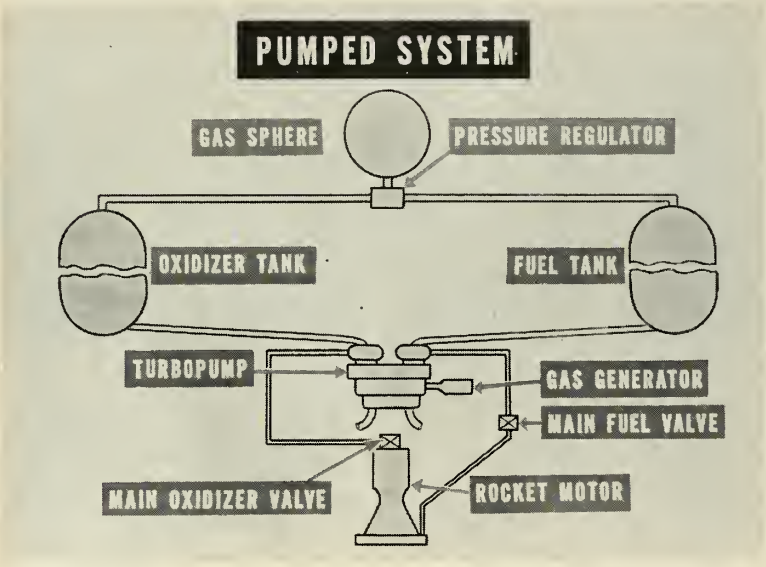
Pressure switches

Engine control unit

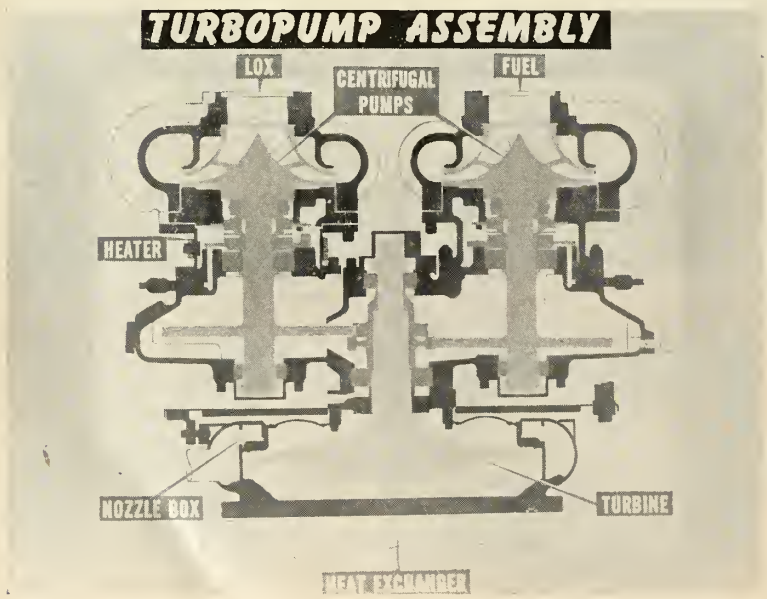
strophic failure. Obviously, total pressure drop in the backplate must be minimized and maintained at a uniform low level to supply the injector holes with a uniform pressure. Velocity within the backplate has less obvious but equally important effects on the distribution of reactant, and also should be maintained at relatively low levels. From the injector, the oxidizer is sprayed into the combustion chamber, where it combines with the fuel to provide the necessary thrust requirement.

• **Operation**—Engine operation is initiated by providing power to a pyrotechnic igniter.

When an electrical signal shows that the igniter is burning, the oxidizer control valve is opened partially and the fuel control valve is opened fully. Propellants, flowing by gravity and the small positive tank pressure, enter the combustion chamber and ignite.



Vanguard pump system and turbopump assembly.



To Powerplant Engineers Facing an ENGINEER | BARRIER *

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Shown here: John Winter, Chief Engineer Powerplants Sub-Division

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Since the oxidizer valve is only partially open, this low-stage combustion is comparatively low in temperature. Low-stage operation is sensed by a combustion indicator which signals the hydrogen peroxide valve to open fully. Hydrogen peroxide enters the gas generator, is decomposed into high-temperature, high-pressure steam and enters the turbine nozzlebox. The turbine starts and builds up to full speed, turning the pumps and providing high-pressure propellant flow.

The propellants then burn at high-pressures and temperatures in the combustion chamber, providing full thrust. Oxidizer flow and mixture ratio is programmed throughout the starting sequence by the spring-loaded oxidizer control valve which opens proportionately to the pump outlet pressure.

Shutdown is accomplished by signaling all three propellant control valves to close. A pneumatic delay, built into the fuel valve, prevents rapid closure and eliminates hydraulic hammer in the fuel lines.

• **Looks easy, but**—As with other conventional rocket engines, the X405 looks deceptively simple in design, construction and operation. But a brief review of the main components and their major design criteria underscores some of the problem.

Looking first at the turbopump assembly it is found that the fuel and oxidizer are fed through lines which are perpendicular to the inlet ports at the top of the assembly. The fluids then discharge through tangential outlets on the periphery of the pumps. Both pumps are driven, through gears, by a single-stage impulse turbine wheel. Both pump shafts and the turbine shaft are parallel to the engine axis.

Gears and bearings must operate at extreme speeds, lubricants must stand up over a wide-temperature range, and propellant seals must operate reliably.

As expected, development difficulties were experienced in modifying the X400 turbopump assembly for use in the *Vanguard* application. Most of these troubles were caused by the increased burning time and higher power output. The lubrication system was changed to provide more adequate cooling for several of the main bearings—as a result, the turbopump is now pregreased and operates for many cycles without component changes.

Power to turn the turbine is provided by the decomposition products of concentrated hydrogen peroxide. Stored in a separate tank, the hydrogen peroxide is forced by helium through a control valve to the turbine-drive gas generator. The hydrogen peroxide valve must be quick in response and reliable in operation. Corrosion is a major problem which can be prevented only by strict cleanliness in preparation and storage procedures.

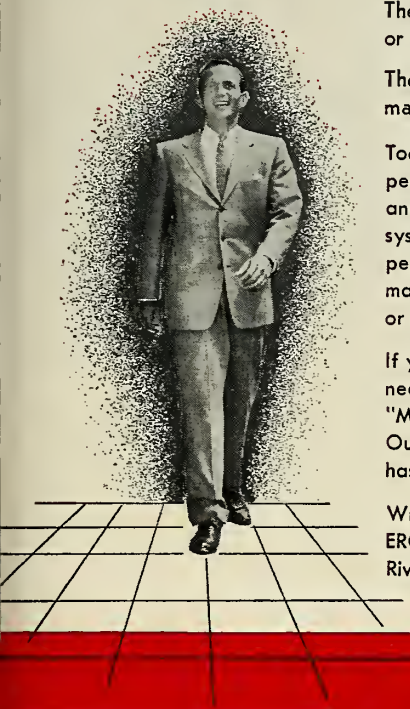
The turbine-drive gas generator contains a silver-screen bed which acts as a catalyst on the 90% hydrogen peroxide, decomposing it into high-temperature steam. Pressure fluctuation and low-efficiency problems, encountered with early units, were solved by a screen pack redesign and insistence on extreme care and cleanliness during the assembly operation.

• **Other Solutions**—The next major components are the fuel and oxidizer control valves. Specific requirements for individual units are:

1. The oxidizer valve must provide tight shutoff as well as proportional control of flow during the start and shutdown transients. A problem with similar units is to provide sliding seals which will operate at the temperature of liquid oxygen.

2. The fuel valve must open instantly and provide tight shutoff control. Fuel must be kept from leaking into the pneumatic control sys-

guidance system experts through ERCO training devices



The guidance system of a missile is critical to its purpose—without the system—or without intelligent handling of the system's equipment there is no effective weapon.

The military must train its "unskilled short-term" personnel to operate and maintain this system—and the question arises . . . How?

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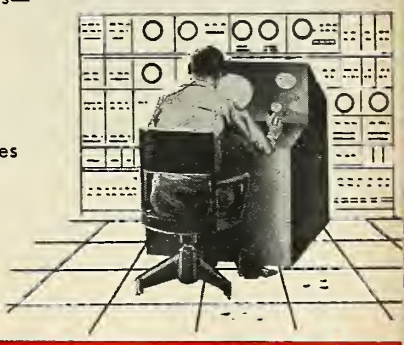

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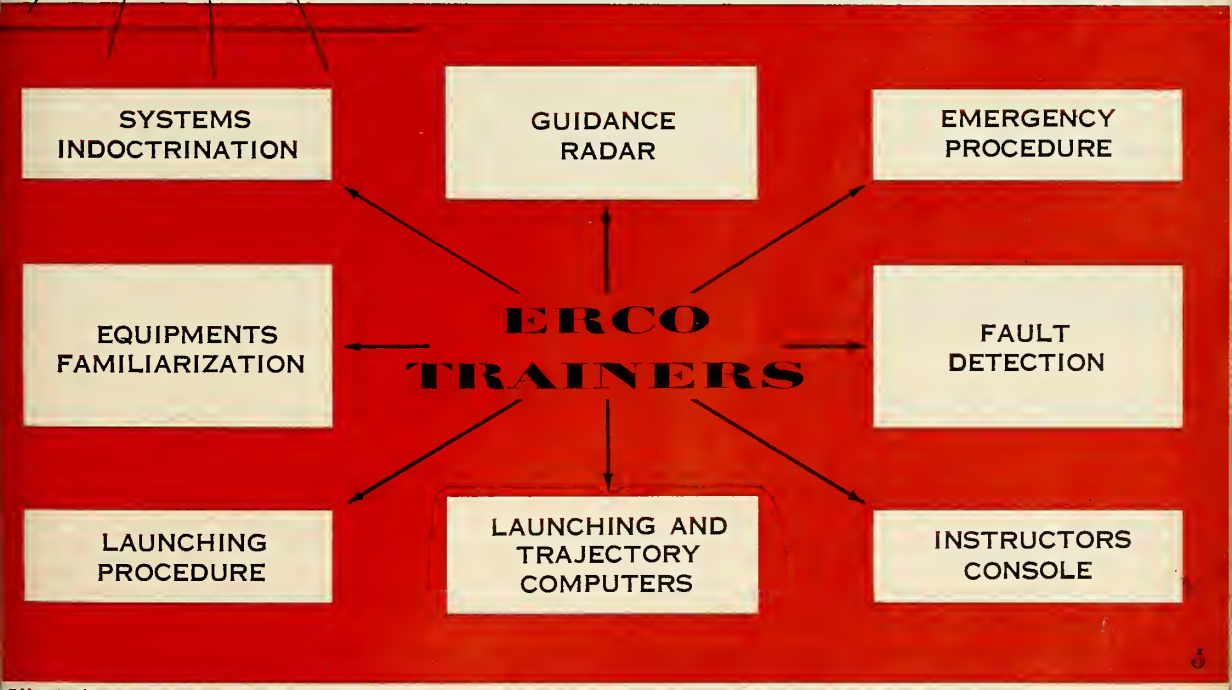

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STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Co., Inc.

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Santa Monica, California

tem. Double O-rings are necessary.

The thrust chamber assembly for the X405 gave the majority of development problems. Injector scoring and inner shell burning were encountered.

On the injector, scoring was evidenced by erosion of the individual injector rings to the point where injector characteristics were sometimes changed. Inner shell burning was characterized by local hot spots in which the metal was burned or melted to an appreciable depth. It should be noted, however, that these conditions usually did not cause static firings to be aborted.

The injector problem was solved by a careful analysis of the gas dynamics conditions, followed by a redesign of the injection pattern. Stringent quality control practices assured adherence to the design requirements. Similar steps were taken with the thrust chamber. A coolant system redesign was followed by strict quality control practices. How well these measures worked is demonstrated by thrust chamber assemblies which have operated for more than 2,100 seconds (about three times the required total operating life) without failure.

• **Thrust Structure**—The X405 thrust structure also presented problems. It had to be extremely light, yet strong enough to receive full engine thrust and provide free thrust chamber movement within a five-degree half-angle cone. Early units were modified to provide the final production item.

In addition, X405 operation depends on several vehicle-mounted and ground-based components. These are:

1—Pressure switches mounted on the pump outlet lines monitor pump discharge pressures and signal propellant exhaustion. This signal is relayed to the engine through the vehicle control system.

2—Engine operation during the critical ignition and starting transient stages is monitored and controlled by an engine sequencer. This unit is mounted in the blockhouse and automatically checks engine parameters, signalling the next step if valves are correct or providing for a safe shutdown in a malfunction.

3—Engine operation in flight and at shutdown is controlled by the engine control unit. Strapped to one leg of the thrust structure, this unit provides the minimum control needed in flight.

When *Vanguard* TV2 was launched, it marked the first time that a large liquid-propellant rocket was flown successfully in this country on its first attempt.

missile age

by Norman L. Baker

• **Bomarc funds**—Many officials working on the *Bomarc* weapons system program feel that the scheduled 5,000 *Bomarc* missile figure will never be realized, for lack of funds if for no other reason. For instance, the launchers, the lowest cost item in the system, would approach $250-million. A delivery of 5,000 *Bomarc* missiles with ground support equipment could easily require a budget of $2.5 billion.

• **Explorer III**—National Academy of Sciences scientists are hopeful that the lifetime of *Explorer* III's orbit is less than that of its batteries. In this case, the transmitters will still be functioning when the satellite re-enters the atmosphere, transmitting invaluable information on re-entry temperatures. The cosmic ray measurements by *Explorer* III is considerably more valuable than those recorded by *Vanguard* I or *Explorer* I.

• **Explorer IV** will be a double-satellite, consisting of an instrumentated payload and an inflated aluminum-foil sphere 12 feet in diameter. Due to its small mass and high reflectivity, the aluminum balloon subsatellite will enable scientists to make more accurate density measurements than can be made with present satellites. Also, plans are underway to orbit four or five 100-foot spheres for experiments in worldwide radio transmission.

• **Liquid propellants**—Die-hard advocates of liquid propellants have proposed a desperation method for keeping current IRBMs and ICBMs on "instant retaliation" standby in an effort to prolong the operational life of these weapons. Air Force officials confirm plans for a continuous fueling system devised to keep the liquid oxygen supply in "topped-off" condition. Missiles reportedly can be fired within two minutes after notification of an approaching enemy missile attack. This promises to be an excellent market for the liquid oxygen generator manufacturers.

• **Talos,** the surface-to-air ramjet missile that has at various times been under the cognizance of all the services, is, for all practical purposes, experiencing a period of suspended development. A member of the Army missile arsenal since June 1957, the *Talos* may never reach operational status. Again, lack of funds plus overlapping capabilities of sister systems (*Nike Hercules* and *Nike Zeus*) may hold further development to a minimum until other systems have forced it out of the picture. Other than the single *Talos* system at White Sands, only one other system (which is now in construction for further evaluation purposes) has been considered. This latest system will not be ready until late fall.

• **Saenger proposal**—The 30-year-old design proposal of Dr. Eugen Saenger for launching a manned globe-circling glide rocket from a rocket sled is finally receiving respectable attention in this country. The design is now reported to be in the final stages of development.

Formica helps solve rocket thermal insulation problems

New Formica thermo-insulator resists hot launching gases

In cooperation with Rocket Fuels Division, Phillips Petroleum Co., Formica application engineers applied a modified FF 34 with precise characteristics for protection against hot gases. The Formica laminated plastics liner protects the steel blast tube of a new target drone through a time cycle of intense heat. Formica's research and engineering staff specializes in developing new and unusual laminated plastics like this — to meet tomorrow's requirements for electronic, missile, rocket and automation equipment. There's no limit to Formica. Its great mechanical strength and heat resistance can be combined to produce the "hot strength" now so important. Formica's many other properties — flame, arc, and chemical resistance; sound and vibration dampening — are equally useful in today's electronic age.

Additional facilities for your new materials development are now available in Formica's new resin laboratory and resin manufacturing plant. For complete information, why not ask your design engineers to write or wire us for free copies of bulletins 852 - 752 and 584.

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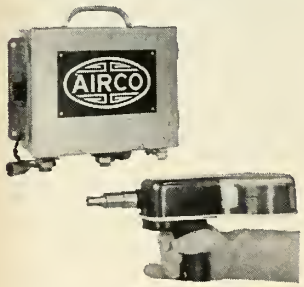
THE NEW AIRCOMATIC® MIGet CAN WELD



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The MIGet features its own compact, built-in reel of wire, high portability and overall light weight. Components of both the Aircomatic MIGet gun and Aircomatic MIGet Control Panel are miniaturized and simplified with sub-assemblies packaged to be replaceable as units.

Your welder may not be working in a crow's nest, but if the job is hard to reach, he'll reach it more easily than ever before and do the job faster with a new Aircomatic MIGet in hand.

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Assess Fuel Binders for Red Rocket Propellants

Typical fuel-binders which Russia may be using with extruded ammonium nitrate propellants are synthetic rubber, polyethylene or polyvinyls, or the double-base materials such as nitroglycerin or diethylene glycol dinitrate.

The use of double-base materials blended with ammonium nitrate appears to be standard for Red artillery rockets and are probably capable of giving a specific impulse in the range 230-245 seconds. This homogeneous-heterogeneous propellant combination would have a much higher burning rate than normal straight ammonium nitrate combinations at the expense of higher combustion temperatures.

Another disadvantage appears to be a relatively high temperature sensitivity Such temperature-sensitivity is believed to be responsible for the development of field heaters as seen on the T-5B and T-5C artillery rockets.

A new extruded, high-burning-rate, ammonium-nitrate double-base propellant powers two of the USSR's operational short-range artillery rockets; T-5B and T-5C. The T-5B is a surface-to-surface missile with a range of 25 miles. It is about 31 feet long, has a launch weight of some 11,000 pounds, and carries a 4,400 pound nuclear warhead.

This missile is carried on a self-propelled launcher—a KW 85 or Joseph Stalin II AFV tank chassis. For cold weather operation, the T-5B is protected by a wrap-around clam-shell type heater.

A smaller version of the T-5B is the T-5C which may use less-temperature-sensitive propellant since its carrier has not been widely seen with a protective heater. The entire missile is smaller since it carries a warhead of 1100 pounds.

T-5C is about 25 feet long, and has a launching weight of about 4,400 pounds. The range is believed to be 15-20 miles. It is not known whether this is a scaled-down T-5B or whether advances in propulsion and warheads have allowed a drastic reduction in missile size.

The small size of the missile allows a much more mobile system than even the T-5B. Photos show that the T-5C is carried by a Type 1955 recon AFV chassis that is fully amphibious. It is significant to note that no US artillery missile of comparable size has been designed for amphibious operations.

In addition to the self-propelled features, both missiles have been designed for airlift use. The use of tank chassis carriers (in particular, the T-5C) have given them all-terrain operation. U.S. missiles are still heavily dependent on vulnerable road nets.

propulsion engineering

by Alfred J. Zaehringer

Demand for fluorine in rocket propellents is low. It is estimated that the US produced 39,000 tons of HF in 1957. Most of this goes into fluorocarbons, high octane gasoline, uranium processing, and some into elemental fluorine. Best guesstimate is that about 1,000 tons of F_2 was made last year, and most of this went to AEC. About 100 tons of fluorine have been consumed by NACA, Bell, Aerojet, and Rocketdyne. Fluorine availability may take a big jump since there is now talk of producing this oxidizer directly from the gravel acid grade fluospar.

Meanwhile, NACA recently released new theoretical performance figures for the liquid hydrogen-liquid fluorine system. At 600 psia, maximum specific impulse is 381 or 392 depending on whether frozen or equilibrium composition was assumed (2740-3400 K). However, a mixture of liquid fluorine and LOX will give better performance with hydrocarbons than either 100% F_2 or O_2. This is due to the preference of fluorine for hydrogen and the carbon for oxygen.

Future for pyrophoric fuels is good, believes Gulf Research and Development Corp. about trimethyl aluminum, triethyl aluminum, and triethyl boron. Advantages for jet aircraft and ramjets are low cost at high availability, and good resistance to flameout at high altitudes. Present disadvantages are toxicity and high reactivity with water and other hydrogen containing compounds.

Boron fuel yet a trickle. A. D. Little estimates that the capacity of the Air Force (Olin Mathieson) and Navy (Callery) boron fuel plants total about 3,400 tons/year. This is only enough exotic fuel to keep a chemical bomber in the air for about 140 hours. This will limit use for extra power only (say 25% of flying time).

Ozonides for super solid oxidants? A Swiss chemical journal reports of work being done on the thermodynamics of solid ozonides such as of trans-stilbene. These ozonides may well be the next step that will push the solids into the ultra-energy class. Some ozonides are reportedly quite stable.

Polyurethanes for composite fuel-binders may be replacing the present standard polysulfide combinations. Rapid cure rate is one big drawback, says Thiokol; also the new resins offer no overall advantage over existing polysulfides. Thiokol is producing both resins. Aerojet-General is also producing polyurethanes which is believed to be going into some of their new solids. One source states that a polyurethane solid system has already been tested at an I_{sp} of over 270 seconds.

Scale-up of solid engines poses a new problem. One solid producer reports that combustion stability worsens with a given propellant as size increases. Small composition variances magnify burning characteristics in a trend from combustion to deflagration to detonation.

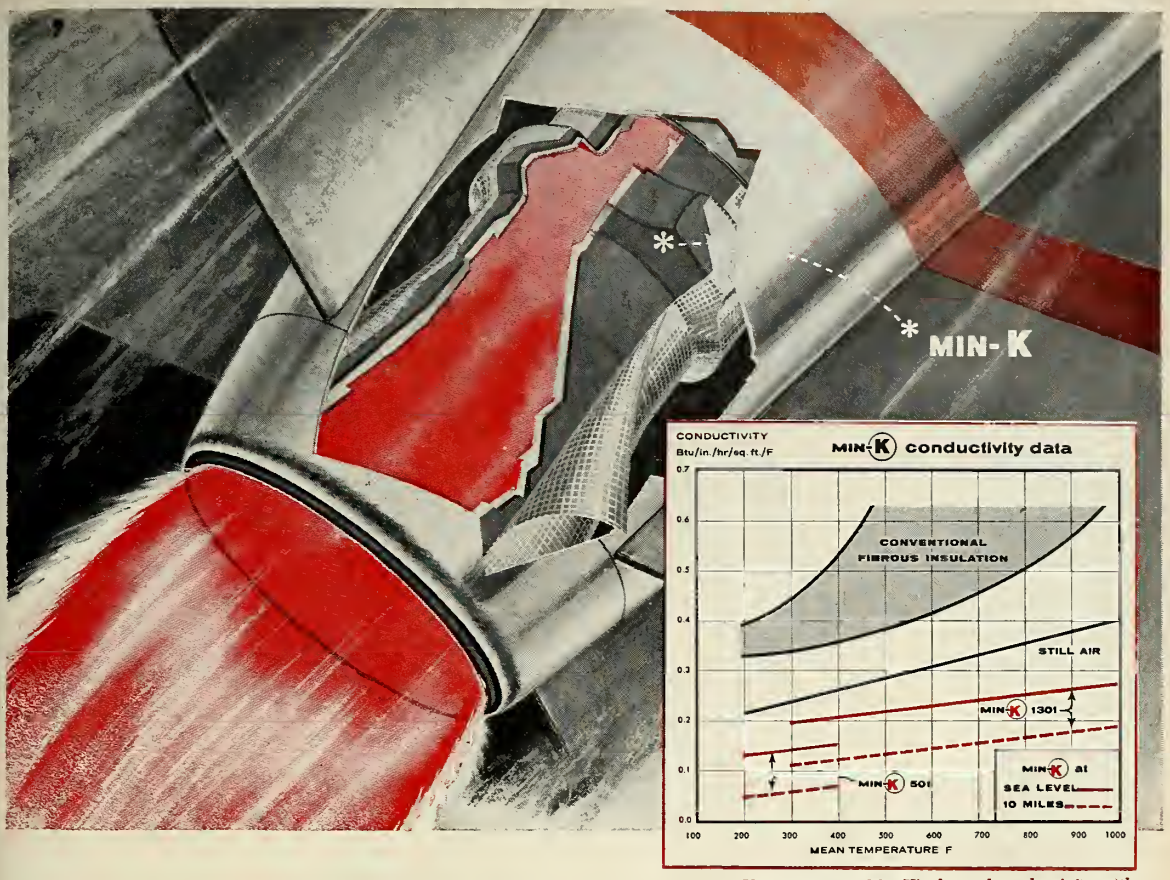

Chart compares Min-K's thermal conductivity with conventional fibrous insulations and still air. Note that Min-K's conductivity decreases with altitude.

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A scientific break-through in missile insulation!

New MIN-K has lower conductivity than still air—performs better the higher it flies

- Saves missile space to boost fuel capacity and range
- Protects instrumentation more effectively to increase accuracy
- Offers lower thermal conductivity than any known insulating material
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Min-K is in every meaning of the term—a scientific break-through!

For in Min-K, Johns-Manville research scientists have developed an insulating material entirely new in concept, an insulation so effective that its thermal conductivity is actually below what was long called the ultimate—the molecular conductivity of still air.

Increases accuracy and range

With this new low in thermal conductivity (less than half that of the best fibrous insulations), Min-K contributes to greater accuracy by providing more effective protection of temperature-sensitive instrumentation . . . increases range by conserving space for greater fuel storage.

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Unique with Min-K is improved performance at altitude, for its thermal conductivity drops appreciably as atmospheric pressure decreases. At an altitude of 10 miles, for example, Min-K's thermal conductivity is decreased by as much as 40%, and further decreases at higher altitudes!

Manufactured by J-M as integral parts—Min-K insulations are precision molded to any shape you specify . . . encased in high-temperature metal foils or laminated to reinforced plastics. Min-K insulations include a wide variety of strengths, densities and temperature resistances.

For detailed information about Min-K, write Johns-Manville, Box 14, New York 16, N. Y. (Ask, too, for aviation insulation brochure IN-185A.) In Canada, Port Credit, Ontario.

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Alamogordo . . .

Where Missiles Bloom In The Desert

by Alfred J. Zaehringer, Norman L. Baker

Photos by US Air Force.

THE MISSILE DEVELOPMENT CENTER is situated in the Tularosa Basin of south-central New Mexico near Alamogordo. It has grown from a World War II base built for the British and used by the Army Air Corps to train bomber crews, to its present permanent status. It was here, in the Northern part of the bombing range, that the first atomic bomb was tested in 1945.

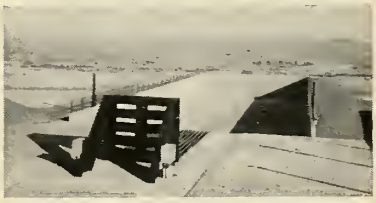
Originally named Alamogordo Air Field, the base was closed for a short period following the war. It was reactivated when the need for a guided missile range arose. A detachment from the Air Materiel Command started to prepare the new base in March, 1947.

The first rocket was launched on September 17, 1947. In 1951, the base became a part of the Air Research and Development Command. Holloman Air Development Center was organized October 10, 1952. In 1957, the name of the base was changed to the present Missile Development Center.

When the base was reactivated in 1947, it had a missile range of 64 miles north to south and 38 miles wide. During that time, the Army Ordnance built White Sands Proving Ground, with a range just to the south of Holloman. At first the two installations worked together, informally scheduling the greatest efficient use of the combined range—100 miles long, 40

AERIAL VIEW of new 35,000 ft. rocket test track. Breech end is adjacent to track at lower left. Track headquarters are housed at right center. White sands at left.

SUNKEN OBSERVATION blockhouse dominates rocket acceleration track's end. Booster storage is in background.

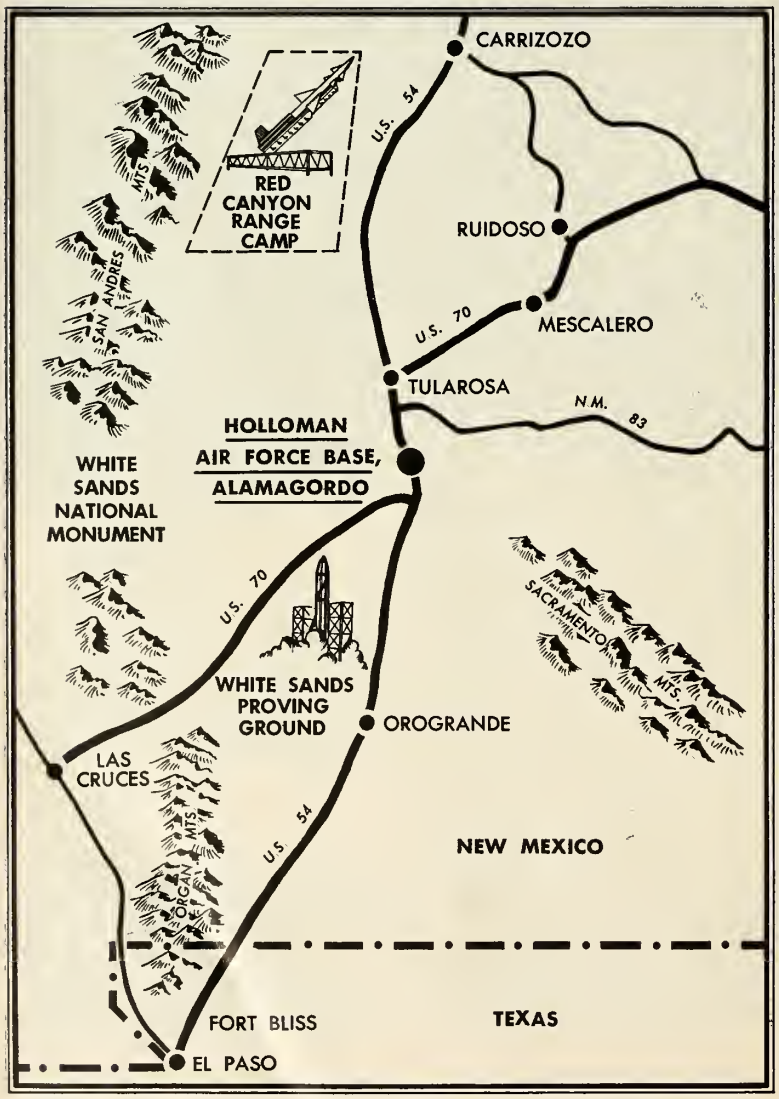


TEST STAND engine mount looking toward water pit used for cooling exhaust.

LAUNCHING AREA complex: Aerobee launch tower, control and tracking van.

THE CITY of Alamogordo, looking South toward El Paso.

PERSONNEL ENJOY winter skiing in nearby mountains.



miles wide at its greatest extent.

In 1952, the operation of the combined range formed the "Integrated White Sands Range." Use of the range is now coordinated by an Army, Navy and Air Force Committee. In the operation of the range, the Army principally provides ground support; the Air Force air support.

• **MDC in action**—In support of the ARDC mission, MDC conducts research and development of assigned guided missile systems and components; tests and evaluates missile weapons systems, missile operational techniques and associated equipment; and conducts aeromedical research and development.

At the MDC location, there are several launching complexes; a 35,000 foot rocket track; a short deceleration track; a million pound thrust test stand; an airfield, tracking stations, and other related missile equipment.

Construction has been completed on a new horizontal test stand at AFMDC. The $510,000 stand, capable of handling a million pounds of thrust, was built by the Robert E. McKee Company of El Paso, Tex.

The stand will test liquid propellant rocket sled powerplants, and for this reason, is located adjacent to the new 35,000-ft. Holloman track. The stand will also test solid units.

The facility is of open-remote construction with concreted revetments for protection—and heart of the facility is the stand. To the side of the stand is an instrumentation and observation blockhouse of direct-view type. To the rear of the stand are three propellant bays. The bay walls are constructed of reinforced concrete.

Directly in the exhaust area is a water pit for quenching the rocket

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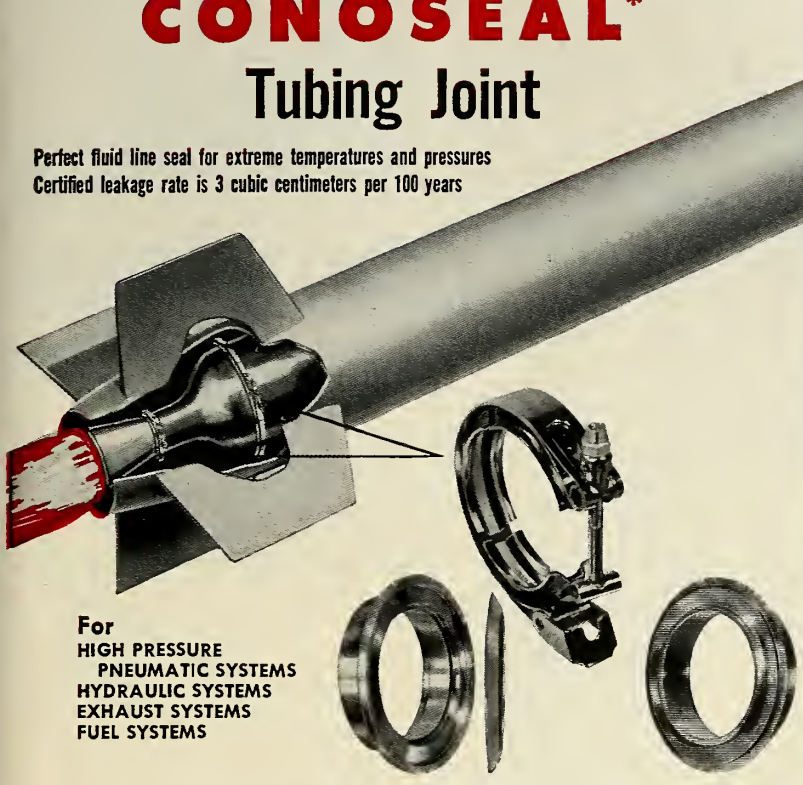

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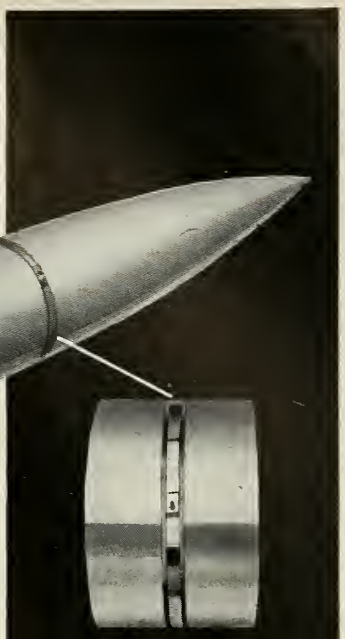

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H. H. "HERM" COLE, at 39, typifies one of our many young "old timers", having joined the firm in 1942, just three years after it was founded. After varied experience in airplane design, Herm was assigned to the Preliminary Design Group of the XF-88 Voodoo in 1946 upon his return from Navy service. In 1952, he was appointed Assistant Project Engineer of equipment and structures on the F-101A, later being promoted to Project Engineer. Presently, he is Project Engineer for all three versions of the Voodoo.

The headlines of our nation's newspapers proclaimed the speed of the F-101 Voodoo after "Operation Fire Wall", conducted in late 1957. Herm's entire project organization deserves special accolades since it was the F-101A model of the Voodoo which established the new world's speed record of 1207 m.p.h. for operational fighters.

MEN OF PROJECT F-101

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flame. In addition, the entire test pad is flooded by a water table and spray nozzles can saturate the stand itself.

At the other end of the stand, a large water supply tank and a pump house are situated. Electrically-operated pumps that can be emergency-operated on internal combustion engines, flood the stand pad and provide the fog spray.

Installation of recording instrumentation in the blockhouse will complete the facility which is scheduled to go into operation this summer.

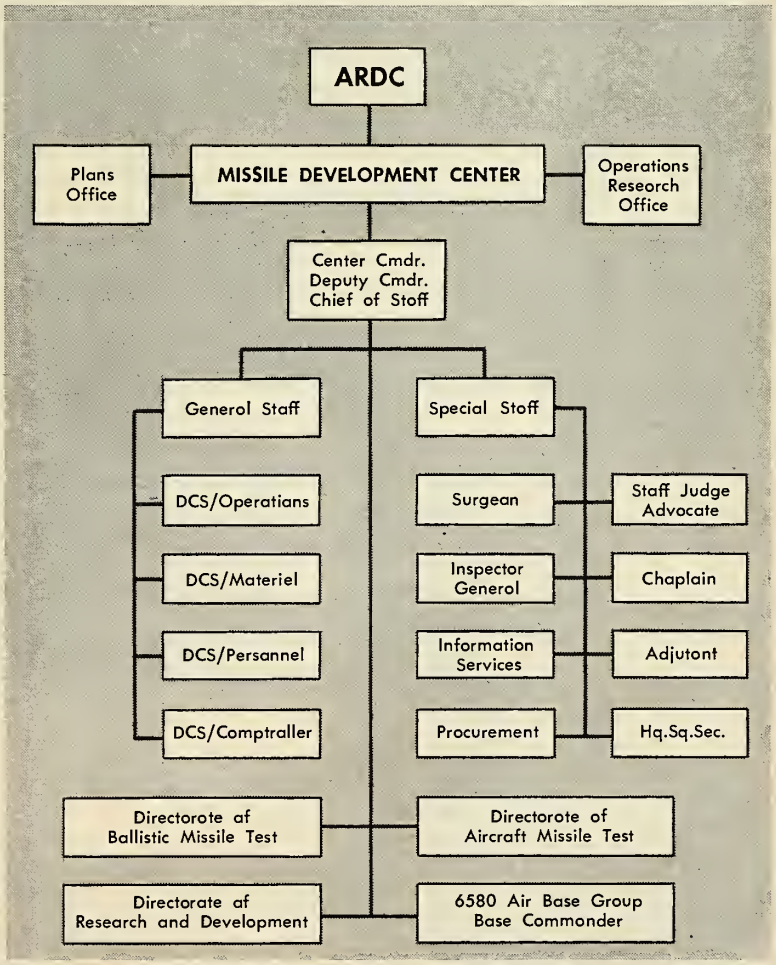
With one 50,000-lb. LOX-alcohol sled engine on hand, the stand is believed to have adequate capacity for some time to come. A closed-loop TV circuit (to be installed) will make indirect test observation possible. Data collection instruments consists of six strip-chart recorders and one 36-channel oscillograph, plus a time-sequence recorder.

Center Commander is Brig. Gen. Daniel E. Hooks. L/C R. L. Sunde is Base Commander; Col. R. E. Keating is Chief of Staff and Col. H. S. Judy is Deputy Commander.

• **Projects planned**—Current missile projects include: *Falcon, Aerobee, Matador, Firebee,* MB-1 atomic warhead rocket, *Rascal,* and the X-7 ramjet. Related work will be concerned with research balloons, ICBM activity, space biology, auto crash research, and solar furnace research.

Many units at MDC support the missile projects, including Air Force and Army tenant organizations. Some of these units are the 169th Signal Company; 3225th Drone Squadron; AACS; AF Weather Detachment 24; 9393rd TSU Detachment 3; and 9577th TSU.

Civilian contractors are Aerophysics Corp.; Bell Aircraft Corp.; Boeing Airplane Co.; Convair Aircraft Corp.; G. L. Martin Co.; Douglas Aircraft; Hughes Aircraft; Goodyear Aircraft; McDonnell Aircraft Co.; Northrop Air-



A simple but precise computer is the brain of Hydro-Aire's famed "Hytrol" anti-skid braking system: a black box that masterminds the braking operation on more than 6,000 airplanes now in use.

This successful production experience — coupled with considerable background in the development and applications of semi-conductors — has led Hydro-Aire into the field of highly reliable electronic system components. Transistorized power supplies, regulators, amplifiers, oscillators — all of advanced design and thoroughly field tested — are now available from Hydro-Aire.

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craft Co.; North American Aviation; Lockheed Aircraft Co.; Ryan Aeronautical Co.; Radioplane; Land-Air; Marquardt; Bendix; Aerojet-General and IBM Corp.

A total of about 6,500 are employed, with an annual payroll of $35 million.

• **Climate and Geography**—Alamogordo, the nearest town, is just minutes away on a dual-lane highway. The town of Alamogordo is on the eastern edge of the Tularosa Valley—about three miles from the foothills of the Sacramento Mountains.

The Tularosa Valley is a closed basin about 35 miles wide, with the Organ and San Andres Mountains forming the western border. The valley extends northward about 50 miles.

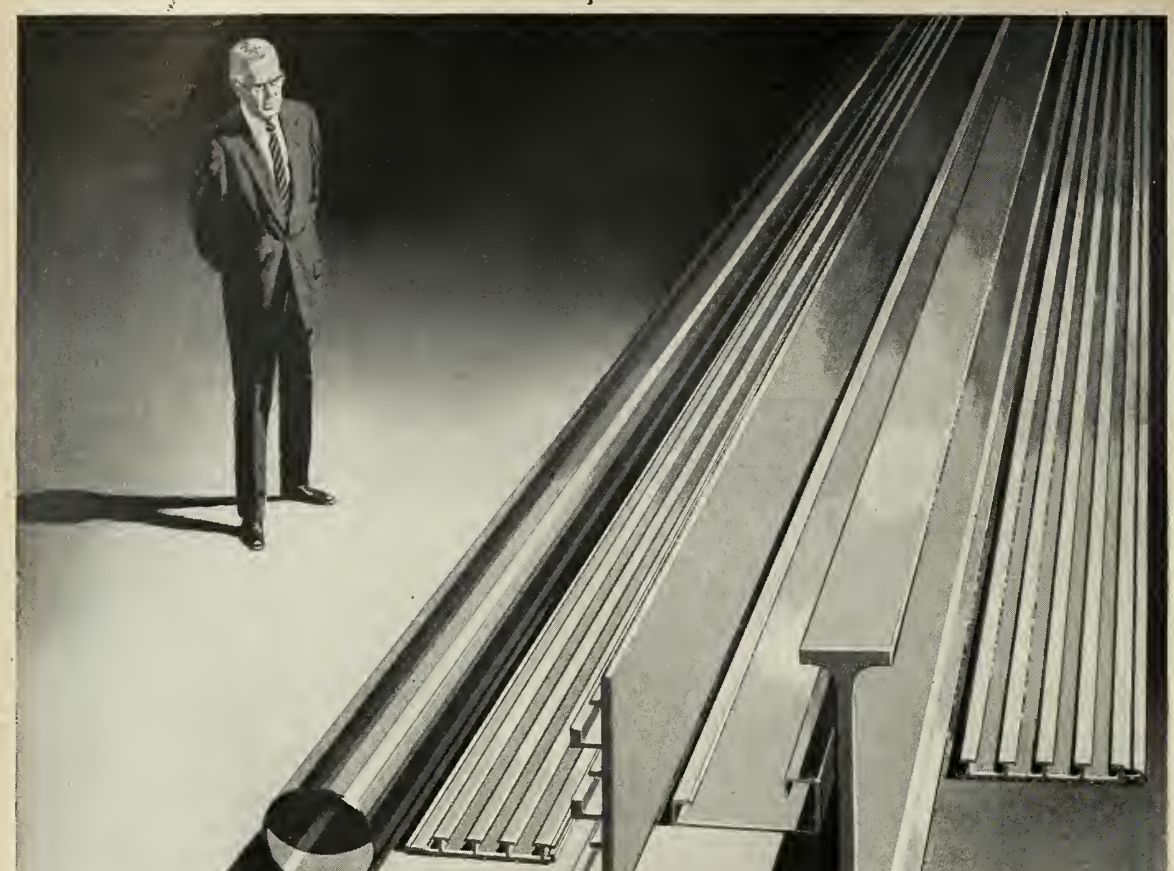
The Sacramento Mountains on the East have a considerable effect on the climate. The mountains rise abruptly from the valley to an average elevation of 7,000 to 8,000 feet, with peaks above 12,000 feet.

Moisture-laden air from the Gulf of Mexico is stopped by the mountains, and also tends to shut out the cold winter air. This gives the valley floor a desert climate. Due to the elevation of the valley floor (about 4300 ft.), the climate is not unbearable.

The average rainfall at Alamogordo is less than 10 inches. Some 58% of the rainfall comes in the summer in brief but heavy thundershowers. Prolonged rainy spells are practically unknown. Even in the summer, there is only an average of 3 to 4 days a month when rain falls one-tenth of an inch. Fall, winter, and spring are even drier. Snow does fall during the winter, but is seldom on the ground for more than 24 hours.

	Mean Temperature (F)		Mean Precipitation
	Max.	Min.	
Jan.	55.0	28.1	0.68
Feb.	61.6	32.6	0.51
Mar.	67.8	37.6	0.40
Apr.	76.8	45.5	0.28
May	85.1	53.5	0.65
June	94.0	62.4	0.60
July	94.2	65.5	1.75
Aug.	92.7	64.2	1.48
Sept.	87.9	58.8	1.48
Oct.	77.9	48.1	0.92
Nov.	65.1	34.9	0.48
Dec.	57.4	29.3	0.50

Average sunshine is 80%, and even in the winter the sun shines 75% of the time. Typical of the desert climate, humidities are low. Relative humidity ranges from 40% to 65% during the cool morning hours, and falls to 15% to 25% in the afternoons. Winds gen-



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missiles and rockets

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erally average about 10 miles per hour.

• **Living Conditions**—On-base housing is improving. A modern Capehart community of 400 units has been added and completion is scheduled in 1958. The current Wherry housing project is being remodeled. In-town housing compares in price to the East Coast, and is easy to buy if down-payments can be met.

Building, evidenced in the housing developments which have been completed in town during the past five years, shows permit valuation of $8,674,502 for 1956 contrasting with a value of $2,297,741 in 1954.

Schools both at AFMDC and in Alamogordo are good. The MDC base school is less than five years old; of masonry construction, and well appointed. Alamogordo has managed to keep up construction of schools and playgrounds, and there is no crowding either on base or in town.

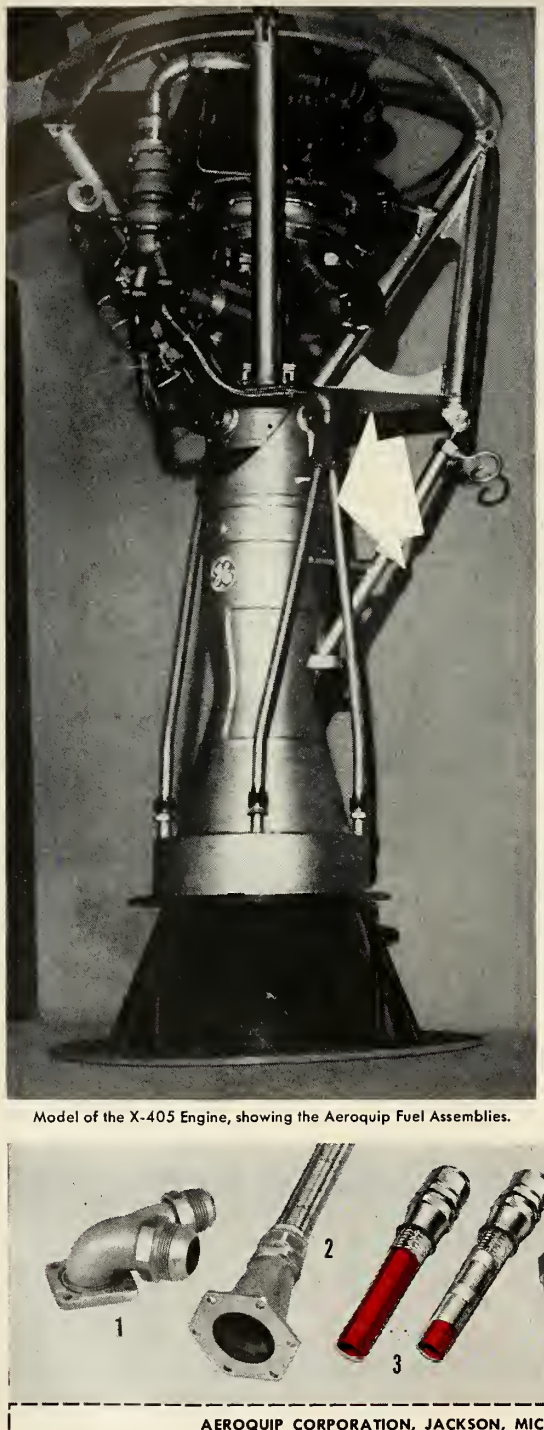
At AFMDC, there is a medical and dental clinic, a new commissary and an Officers Club under construction. Airmen have a swimming pool; officers will complete theirs this summer. On base, there are three TV channels from El Paso. "Townies" subsist with one VHF channel.

• **Area trends**—Alamogordo is the county seat of Otero County. Cotton, truck crops and feed are raised in the valley under irrigation; stock is raised on the plains and mountains. Considerable fruit is grown in the mountain valleys. The town has grown from a population of 6,700 in 1950 to over 19,000 in 1957. School enrollment is 5,500.

Lumbering is prominent in the Sacramento Mountains where several lumber camps are located. Lumber manufacturing itself places first on the list of major industries in Alamogordo in order of employment significance.

Cattle and sheep ranches dot the surrounding rangeland—the Mescalero Indian Cattle Growers Association alone averages over 2,000 head in sales each year. Much of the range land on which cattle were run in the early days has now been leased by the government for use in rocket research and artillery training.

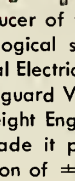
•**Town of progress**—Alamogordo is growing at the rate of about 200 people per month. Three churches have been completed and two are in construction. The city has its share of new stores and super markets, but many people still shop by catalogue.



Model of the X-405 Engine, showing the Aeroquip Fuel Assemblies.

problem: design fuel manifolds to accommodate gimbal action on the first stage Vanguard engine

Aeroquip Solved it with High Performance Hose and Tube Assemblies



Aeroquip—leading producer of flexible hose lines *AND* precision tubing—was the logical source for the two fuel line assemblies on the General Electric X-405 engine that powered the first stage of the Vanguard Vehicle.

Aeroquip 601 Lightweight Engine Hose, used in connection with tube assemblies, made it possible for the fuel lines to adjust to the gimbal action of ±5° in either plane to control the vehicle's direction.

Other Aeroquip products on the Vanguard included High Pressure Hose Lines for the hydraulic system, and KEL-F Hose for the safe transfer of nitric acid during fueling.

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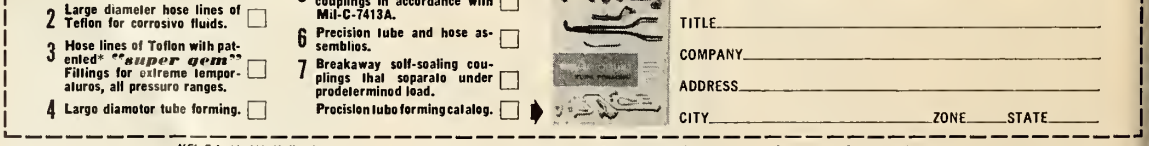

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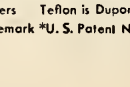
Precision tube forming catalog. ☐



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KEL-F is M. W. Kellog's trade name for fluorocarbon polymers Teflon is Dupont's trade name for its tetrafluoroethylene resin
"super gem" is an Aeroquip Trademark *U. S. Patent Nos. 2,833,567 and 2,731,279

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Alamogordo's growth is reflected in the communications of the city, which has progressed rapidly in 1957. The telephone system of over 4,500 instruments was converted to dial on May 4. THE ALAMOGORDO DAILY NEWS, the local newspaper, went to a six-day publication on April 1. The county weekly, "The Tularosa Basin Times," went to press for the first time on March 7. A second radio station, KRAC, went on the air in June, joining KALG which is only seven years old.

Alamogordo now has 660 shops of all types, with more under construction continuously. The town offers a metropolitan life to the former big city dwellers who have come here to work in rocket research.

However, Alamogordo still maintains a small town atmosphere. It still is enough of a small town to fill the personal needs of its residents through the columns of its weekly paper.

Alamogordo is also served by excellent transportation facilities—daily service by Continental Airlines, Southern Pacific Railroad, truck lines, New Mexico Transportation Company buses, and even charter plane service. The founding fathers in 1898, and their successors, never dreamed of the rapid growth of the town which would follow the explosion of the atomic bomb.

• **Recreation**—The area is rich in recreational activities. Just five miles from the base is the White Sands National Monument with 224 square miles of pure white gypsum dunes.

The rock enthusiast can spend hours in the various canyons in the land of the Apache, and he can also visit Dog Canyon, one of the last strongholds of the Apaches.

On State Road 83 is Cloudcroft; with a $100,000 summer resort hotel, The Lodge. The village boasts the highest golf course in America, and air conditioning by nature. Its ski run is the main attraction in winter.

Indians can be seen at the Mescalero-Apache Indian Reservation at Apache Summit; where dancing shows are put on during Puberty Rites. Also, not to be missed is the Billy the Kid pageant at Lincoln during August.

And there is always the big town of El Paso, 80 miles away. Across the bridge from El Paso is Juarez, Mexico. Juarez features bull fights; hot spots; and many shops which carry leather, jewelry, and liquors, plus gin and rum for ninety cents a quart and 120 proof vodka for $1.20 a quart. Other tourist points include Carlsbad Caverns and Big Bend Country.

- Conductivity equal to that of copper with only **47% of the weight.**
- Termination and solderability properties of the best silver plated copper.

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missile miscellany

Shell Development Company is working on a fuel that will be immune to radiation, for use in A-plane's auxiliary power plant . . . Japan has fired two Kappa-150's with a .500 batting average . . . Canada will build Sparrow II . . . One of the big problems that must be solved before 1,500-mile Polaris is a fact is the successful fabrication of a 230,000 psi yield strength thin-wall, high-strength casing for the solid propellant motors . . . This page has had it reconfirmed that Thiokol "is definitely not out of the Polaris program."

Soviet Embassy officials in Washington are now peddling the line that a moon rocket is just a political stunt, that it has no scientific value—they're talking about probes shot at the moon, rather than the landing of instrumented packages on the moon. Could mean that they don't plan a moon shot before the U.S. will try it—sometime this fall . . . Army's moon rocket project's called *Juno-II*. Question. What was *Juno-I?*

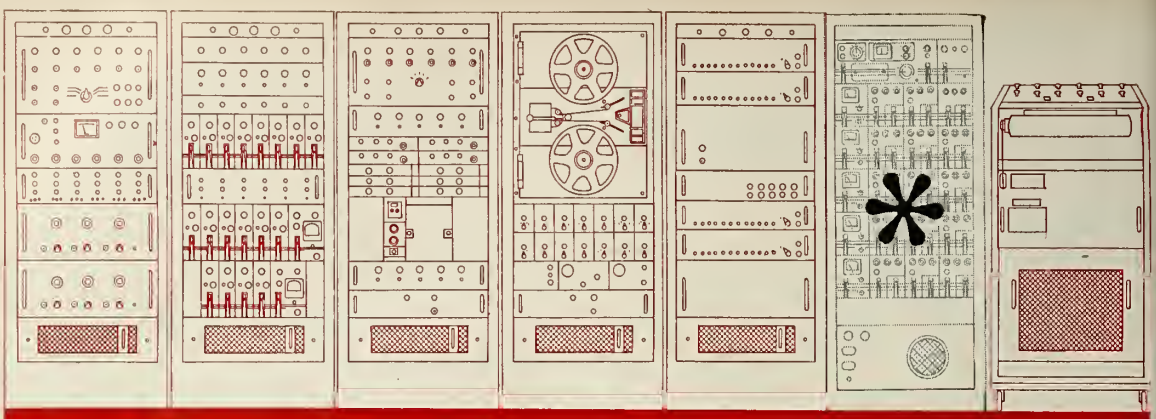
Ten Atlas missiles at their launching site will represent less than 20% of the total site cost, with 40% for ground support, 10 per cent for spare parts and 30% for technical facilities . . . If the President Eisenhower's plan for concentrating more money power in the Defense Secretary's hands goes through, look for interservice rivalry to get even more that way.

This page can't wait to see the result of a plan now afoot for unveiling a "monstrous big rocket," in which all four services participate, on Armed Forces day . . . Which is as good an excuse as any to throw one out to the Relativity experts: What happens to Einsteinian theory when you consider what you would get measuring the closing gap between two rays of light from two sources in opposition that were turned on simultaneously—twice the speed of light?

The big Pentagon fuss about m/r's story last month on Subroc turned out to be a matter of security all right—Navy League security! . . . And the other day this page happened into National Airport at a time when Wernher von Braun and John Hagen met in passing—one going and the other coming—and overheard one say as they parted: "So long, see you in orbit" . . . Speaking of missile men, Commander Bob Truax's orders returning him to Washington and the Navy's Special Projects Office have been cut and approved.

Test of Atlas guidance system is proceeding satisfactorily in an RC-121 Connie at General Electric flight test center in Schenectady . . . Meanwhile, a new and important science may be developing in what might be called "trace waves." These would be electromagnetic phenomena of a very low order of power, study of which is made possible by refinements in detection and filtering circuitry . . . At the same time, word of work on an entirely passive electromagnetic homing system for missiles, employing the Zenneck wave phenomena.

SEABROOK HULL



HALLAMORE PHASE-LOCK DISCRIMINATORS

ELIMINATE SYSTEM ERRORS . AFFORD ECONOMY AND SPACE SAVING ADVANTAGES –

This Hallamore developed building-block type FM telemetry system is designed to condition and calibrate signals from any combination or multiples of the following transducers: potentiometers, flow pickup, bridge, thermocouple or differential transformers. Hallamore manufactured elements in the system include DC amplifiers, S.C.O., summing, universal calibrator, calibrator test instrument, tuning system and the discriminator station. Hallamore phase-lock discriminators, Model 0162, reduce subcarrier frequency information to output data relatively undisturbed by noisy signals which contribute to the inefficiency of pulse counting type discriminators.

Designed around a concept entirely new to the telemetry field, the Model 0162 phase-lock discriminator eliminates signal suppression by noise, non-linearity by filtering, and thresholding at low signal to noise levels. In addition, the unit occupies less space, reduces overall system cost, and assists in the simplification of operational procedures. For complete specifications and operational data, write Hallamore Electronics Co., Dept. 87, 8352 Brookhurst Avenue, Anaheim, Calif.

HALLAMORE ELECTRONICS COMPANY

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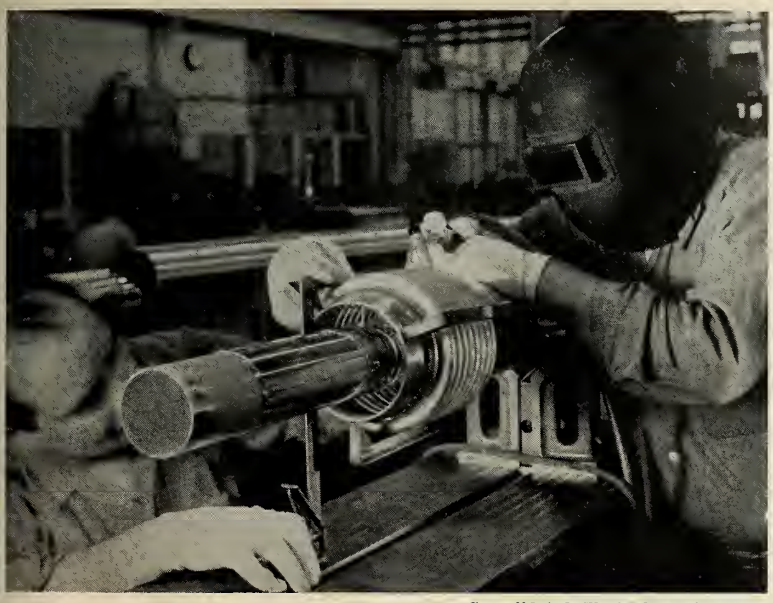


Consolidated Electrodynamics Corp.

Vacuum-Jacket Lines Save Fuel

BOIL-OFF LOSSES of low-temperature liquid fuels for rockets and missiles have been virtually eliminated by using high-vacuum jacketed transfer lines.

Pipelines are being used at missile launching sites because of difficulties of scheduling truck deliveries and proper timing of unloading without creating traffic jams. Presence of trucks also creates extra hazards, and the tendency today is to fuel the rocket through a transfer line from a storage tank or generator located at a suitable distance and in an area convenient to all launching pads.

But piping is a major problem. Uninsulated lines—first used as a matter of expediency in getting rocket test facilities into operation—depend upon the coating formed by the freezing of atmospheric moisture for insulation. There is considerable boil-off, however, during the chill-down period, and in warm areas where the ice build-up is rapid, flaking-off also can be pronounced, exposing considerable areas to added boil-off.

Recently, asbestos, foamglass, cork, and glass wool have been used for insulation. They are an improvement over the natural snow coat on uninsulated lines but their efficiency is difficult to assess. However, conventional insulation requires chill-down period and large amounts of the low-temperature liquid fuel may boil away. At some stages of the chill-down process, increasing the thickness of the insulation may cause more boil-off. Condensation and resultant freezing within the insulation can destroy the insulation's thermal qualities. Use of vapor seals cause further complications.

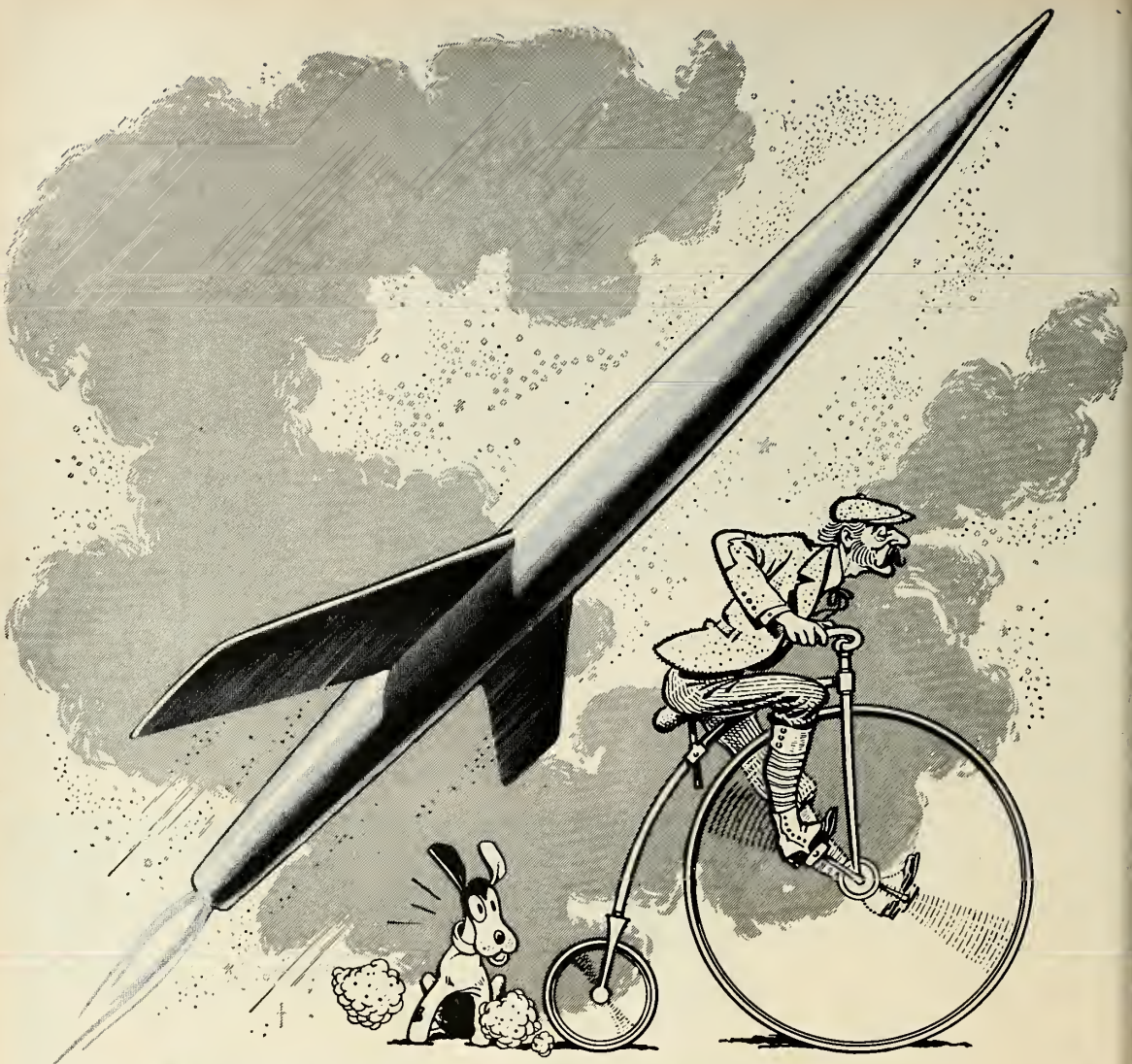
•**New development**—Research has resulted in development of high-vacuum jacketed transfer lines by the Rochester, N. Y., Vacuum Division of Consolidated Electrodynamics Corporation.

Because heat transfer as small as 5.5 to 8 Btu/ft/hr. is possible, CEC claims that the new transfer lines can give fuel savings up to 50% over conventionally insulated lines. Even greater savings are possible over unjacketed lines.

Each section of the fuel bearing line first is treated on the outside to reduce radiant heat transfer and then is surrounded with a vacuum jacket which is pumped to a pressure of 1 x 10^{-5} mm Hg or lower. This cuts both direct and convection heat transfer.

Unusual features of the vacuum-jacketed transfer lines are the bayonet-type joints providing positive leak-proof connections between sections.

The flange in the female joint has been designed so the "O" ring will be completely captured. This eliminates the nuisance of slight jarring, which might cause the "O" ring to leave the flange. All mating machined surfaces have a 63 micro-inch finish. The bayonet connection tolerances are held to 0.0005 inches, when measured on the diameter.



Seventy-five Years ◇◇◇

TEN MILES an hour was "speed" in 1883 when Wyman-Gordon started to make forgings for the high-wheel bicycle. Through the 75 intervening years forgings have made important contributions to the phenomenal advances in propulsion. Progress from the first "horseless carriages"...from the early "flying machines"...to the supersonic speeds of today ...would not have been possible without forgings produced by the most advanced techniques of the day.

Wyman-Gordon is proud of its achievements in these fields and, as the largest producer of automotive and aircraft forgings, is prepared to accept the challenge of the future. Today, as for 75 years, there is no substitute for Wyman-Gordon quality and experience.

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world astronautics

by Frederick C. Durant III

From Great Britain comes word that their 2500 mile IRBM, the *Big Feller* (sic!), will be used to launch a satellite. This project has been reported to have "the highest priority."

A letter to The Daily Telegraph after failure of the second (fungus-bearing) *Vanguard* began: "Yeast-lovers all over the world will have been shocked at the news . . . "

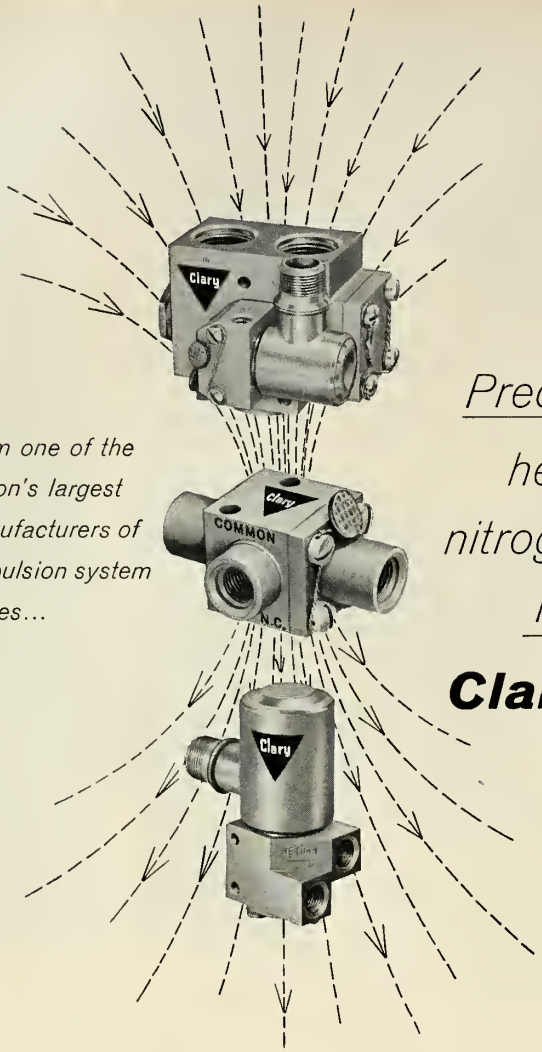
From Japan, the president of the Japan Astronautical Society writes that JAS has organized 30 of the 78 Moonwatch optical tracking teams. As of February, these volunteer groups have turned in 188 observations of 1957—α (*Sputnik* I) and 299 of 1957—β (*Sputnik* II). These reports were made to the Tokyo Astronomical Observatory and radioed through U.S. Navy channels to the moonwatch center at the Smithsonian Astrophysical Observatory.

The Hot Water Jato developed at Forschungsinstitut fuer Physik der Strahlantriebe at Stuttgart has been so successful that plans are proceeding for a launcher of 440,000 lb/sec total thrust. Director of the Institute is rocket pioneer Dr. Eugen Saenger, current president of the DGRR.

Space Medical Experts exhibited irritation recently at the long lead time assigned to manned space flight by the Killian Committee. At the annual meeting of the Aero Medical Association, many privately expressed the opinion that the committee has been too conservative. Their conclusion: Space medical problems of man can be reduced to calculated risks. Cosmic radiation is no longer considered a bar to satellite flights of a few days' duration. Longer trips—perhaps. Solar flares might be a serious hazard.

They agreed that effects of prolonged weightlessness posed questions that may not be adequately answered before man is exposed. In their words, under extended periods of zero-g: (1) "Would psychological effects of apprehension, fear and anxiety affect human physiology?" (2) "Can man perform effectively after prolonged periods of sensory deprivation? Current evidence indicates a six-hour exposure under conditions of reduced sensory stimulation leads to hallucinations and possible psychotic reactions." (3) "Will muscle fiber degenerate?" (4) "Will the reflexes that control homeostasis function normally?" (5) "Could weightlessness cause panic that may lead to total incapacitation of the subject?"

Special Flights to the Ninth Congress of the International Astronautical Federation (Amsterdam 25-30 August) are being arranged by The American Rocket Society. Two departure times of these tourist fare flights are tentatively scheduled: 20 and 23 August. For details, write IAF Flight, c/o ARS, 500 Fifth Avenue, New York 36.



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Precision control of helium, corrosive liquids, nitrogen, air, LOX...and hydrogen peroxide...with*

Clary valves

Here are valves that handle all types of gases and liquids, including *hydrogen peroxide*... valves that feature zero leakage, choice of actuation, "0" ring seals, and *rated operating pressures of 4500 PSIG*... tested, proven valves ranging in tube size from ⅛" to 1½"! Here are valves engineered and manufactured by Clary – the company whose long experience, outstanding staff, and *complete facilities for extreme environmental conditions testing*, have made it one of the nation's largest manufacturers of rocket and missile valves. When precision, reliability and versatility are factors in your plans, call on Clary for complete services.

PILOT ACTUATED VALVE, 3-WAY, NORMALLY OPEN OR CLOSED
Rated Operating Pressure: 4500 PSIG.
Burst Pressure: 7500 PSIG.
Voltage: 18-30 DC.
Connector: Bendix CD 3102-12S-3P.
Leakage: Zero.
Seals: "0" rings compatible with media.
Ambient Temperature Range: –65°F to +250°F.

SHUTTLE VALVE, NON-INTERFLOW
Rated Operating Pressure: 4500 PSIG.
Shuttle Operating Pressure: 15 PSIG.
Leakage: Zero.
Ambient Temperature Range: –65°F to +160°F.

SOLENOID VALVE, 3-WAY, NORMALLY OPEN OR CLOSED
Rated Operating Pressure: 4500 PSIG.
Voltage: 18-30 DC.
Connector: Bendix CD 3102-12S-3P.
Leakage: Zero.
Ambient Temperature Range: –65°F to +160°F.

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**Under development*

Scientists Sub For High School Teachers

Hughes Aircraft Company scientists, attending the Institute of Radio Engineers meeting in New York, subbed as guest lectures in two high schools as part of a "pilot" project to help advance scientific knowledge in secondary schools.

Lecture subjects included generation of microwaves, effects of nuclear radiation on electronics equipment, physic problems connected with automatic pilots, measuring nuclear radiation dosage absorbed by exposed personnel, and high polymer in theory and practice.

Three years ago Hughes initiated a similar program on the West Coast to bring working scientists into the classroom to show current applications of mathematics, physics and chemistry.

The project is expected to be enlarged next year with the help of IRE members from other industries.

Hughes personnel who participated are Dr. John W. Clark, manager of the Nuclear Electronics department, Physics Research Laboratory; Dr. Sam Sensiper, director of the Analysis and Circuits Wave section of Microwave Tube Department II, Electron Tube Laboratory; Dr. George Turin, research physicist; Bruce McVey, manager of the Systems Evaluation department, Airborne Systems Laboratory; Joseph Cryden, physicist and director of the Technical Information office at Hughes Aircraft Company; and Max Bart, engineer and chemist.

Careers . . .

William B. Wassell has been named standards engineer at Chandler-Evans Division of Pratt & Whitney Co. and **W. Marshall Youmans** has been appointed chief draftsman of the company. Wassell, who joined Chandler-Evans in 1950, has been senior designer of the division since 1954. You-

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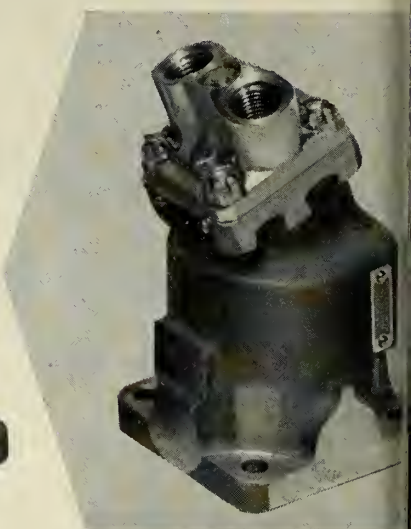
Variable Pump Design Breakthrough!

...by VICKERS

Variable hydraulic output from constant displacement package

NEW MINIATURIZED
VARIABLE DISPLACEMENT
3906 Series ■ Weight...2.4 lb



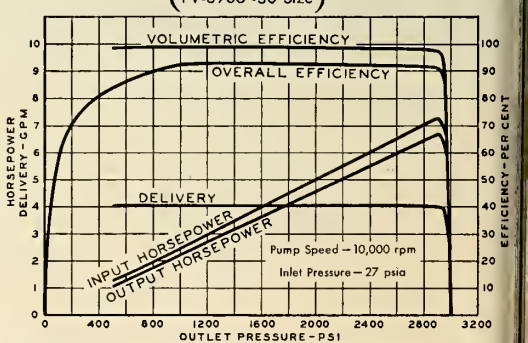
STANDARD
CONSTANT DISPLACEMENT
3906 Series ■ Weight...2.1 lb

- 48% weight reduction—70% smaller envelope*
- 12,000 rpm for aireraft applications
- 18,000 rpm for missile use
- 24,000 rpm for intermittent duty
- 9.7 gpm delivery at 24,000 rpm
- 17 hp (over 7 hp/lb) at 24,000 rpm and 3000 psi
- 98% volumetrie effieiency—92% overall efficiency
- Uses proven Vickers 3000 psi rotating pumping element
- Integral automatie pressure compensator
- Extremely rapid response
- Minimum external sealing elements
- Minimum number of moving parts*
- Broad range of control methods availab.e
- First of a new complete line
- Power saving (and heat rejection) advantages of variable displacement at fixed displacement weight and envelope.

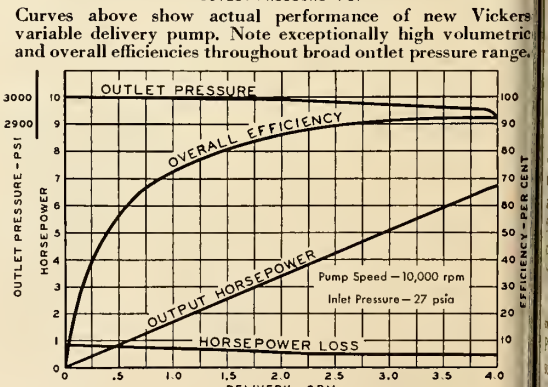
*Compared to standard 3000 psi Vickers Series PV-3906 variable displacement axial piston pump.

For further information write for Bulletin No. A-5233.

Performance Characteristics of Model E-0011111 Pump
(PV-3906 -30° Size)



Curves above show actual performance of new Vickers variable delivery pump. Note exceptionally high volumetric and overall efficiencies throughout broad ontlet pressure range.



Actual test data demonstrating high overall efficiencies even at partial flows for the new Vickers variable delivery pump. Note low horsepower loss throughont entire delivery range.

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. . . missile people

mans joined the company in 1955 after serving four years as a designer at Hamilton Standard in Windsor Locks, Conn.

Dr. Alfred B. Focke, physicist, has been appointed chief scientist at the U.S. Naval Missile Test Center, Point Mugu, Calif. He will be principal advisor to RAdm. **Jack P. Monroe,** commander of the center, on scientific and technical policy, professional civilian personnel and advisor to personnel of the test and evaluation facility of the Center.

James J. Kerley has been appointed manager of financial analysis for Avco's Crosley Division, Cincinnati. His most recent position was manager of forward program analysis in the controller's office of Ford's Mercury Division.

Jack M. Beauchamp has been named director of field service for the Aerojet-General Corp. Beauchamp served as regional representative and district manager of the company's Customer Relations office in New York City.

Anthony J. Krol has been appointed chief chemist of the Callery Chemical Co. of Pittsburgh. He will be situated at the company's new commercial plant at Lawrence, Kan. He formerly worked as a group leader in methods development, and coordinator for analytical matters at the company's Research and Development Division, Callery, Pa.

Alan Borch has been appointed chief engineer at the Empire Devices, Inc., Amsterdam, N.Y. He was formerly chief, magnetics engineers, of Emerson Radio and Phonograph's Government Electronics Division.

Capt. Howard Thomas Orville (ret.), former chief aerologist for the U.S. Navy, has been appointed vice president of Beckman & Whitley, Inc., San Carlos, Calif. He will assist the Instrument and Missile Products Divisions and the board of directors in long-range scientific and technical planning.

Maj. Gen. Kenneth P. Bergquist has been appointed ARDC deputy commander for Air Defense Systems Integration at Andrews AFB, Md. He was formerly assistant chief of staff, Operations, Headquarters, U.S. Air Force.

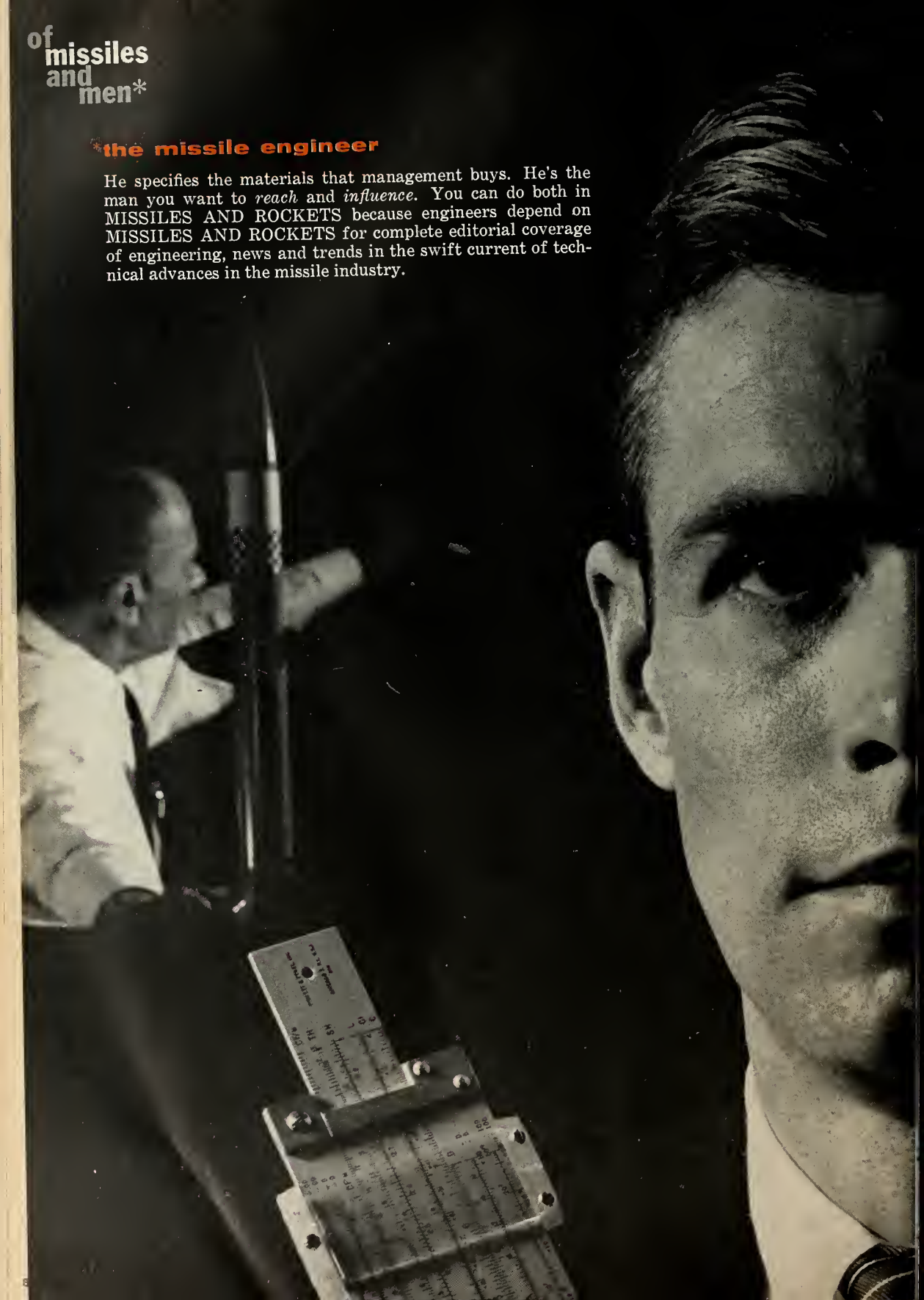
Alfred B. Rossip has been named as transistor sales manager and **Herman Bloom** as components sales manager by the General Transistor Corp. for germanium and silicon diodes, silicon medium power rectifiers and bobbinless precision wire wound resistors.

O. Franklin Frost has been named equipment sales manager for AC Spark Plug Division of General Motors to succeed **K. K. McGarvey,** who is going

of missiles and men*

*the missile engineer

He specifies the materials that management buys. He's the man you want to *reach* and *influence*. You can do both in MISSILES AND ROCKETS because engineers depend on MISSILES AND ROCKETS for complete editorial coverage of engineering, news and trends in the swift current of technical advances in the missile industry.



You reach the missile engineer

in the annual engineering progress issue of Missiles and Rockets ... JULY 28, 1958

Missile engineers look to every issue of MISSILES AND ROCKETS for vital editorial information, but the Annual Engineering Progress Issue is especially important because it contains data and progress reports that will be used for reference time and time again. In addition to the regular M/R features covering the planning, technological and business trends of the industry, the ANNUAL will give a complete summary of progress in the Army, Navy and the Air Force missile programs.

INCLUDES A NEW AND EXPANDED GUIDED MISSILE ENCYCLOPEDIA

The new authoritative Guided Missile Encyclopedia will contain complete tabulation of data with photographs and names of contractors of every missile in operation or under development in the U. S. today (as far as security regulations will permit). The addition of the Encyclopedia to the ANNUAL assures you of high readership. Last year's Encyclopedia is now in its fifth reprinting.

MISSILES AND ROCKETS RECEIVES RECORD BREAKING ACCEPTANCE

23,000 *paid* subscribers demonstrate the acceptance of M/R among missile men in this multi-billion dollar market. 431 individual advertisers since M/R began publication in October, 1956 demonstrate the wide acceptance of M/R as the number one medium to reach this market. Because of the demand of subscribers and advertisers, M/R will be published weekly starting July 7, 1958. Closing date for the July 28th Engineering Progress Issue will be July 7. Contact your nearest regional office for additional information.

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MISSILES AND ROCKETS

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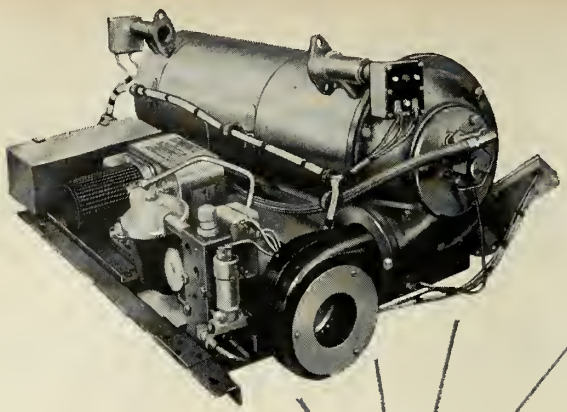
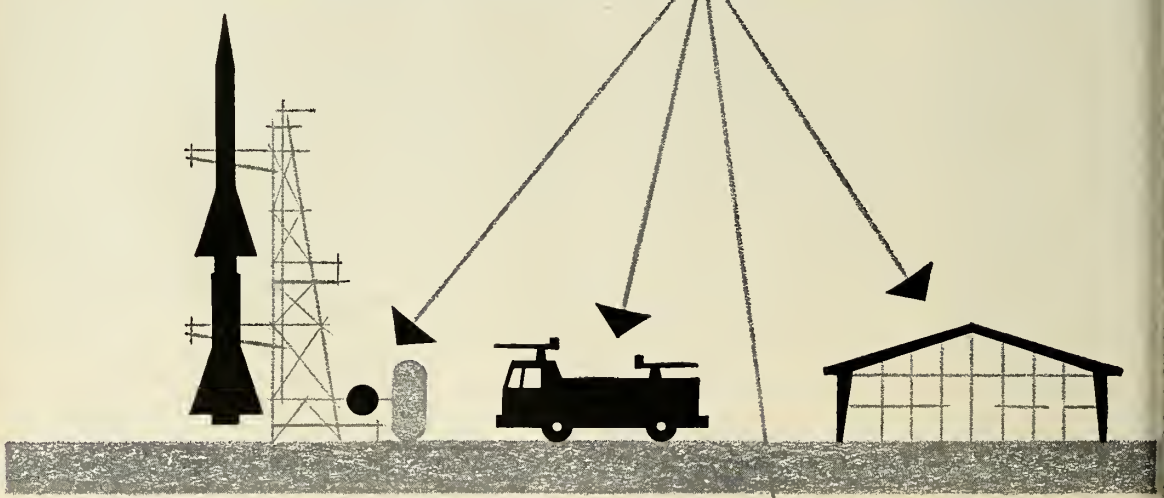


reliable heat for ground support



The Janitrol line of liquid heaters provides versatile packages ranging in capacity from 90,000 to 1,000,000 Btu per hour. They provide reliable heat—at specified temperature—for vaporizing or maintaining temperatures of missile fuels, for instant engine starts in any weather, windshield defrosting, comfort for personnel, cargo and equipment protection.

Liquid heater reliability is a result of refinement and design simplification over a period of ten years of production. Proved in Arctic and Antarctic use, they are already serving in fire crash trucks, prime movers, ice removal units, and in heating decontamination and cleaning fluids.

We'd like to discuss with you any heat requirements you have for missile handling and ground support equipment or vehicles—for fuel processing or for protection of equipment and personnel. Call in your Janitrol representative.

Janitrol Aircraft Division, Surface Combustion Corp., Columbus 16, Ohio.

JANITROL®

pneumatic controls • duct couplings & supports • heat exchangers
combustion equipment for aircraft, missiles, ground support

on special assignment prior to retirement in September. Frost will be in charge of sales of AC original equipment to GM car divisions and other manufacturers.

Lt. Col. Louis H. Wilson (USAF-ret.) has been named to head the newly activated Colorado Springs, Colo., office of RCA Defense Electronic Products.

Thomas I. Paganelli, manager of General Electric's missile detection systems section, has been named head of the project team that will supervise the engineering, production and installation of a super radar system which will become part of the overall Air Force Ballistic Missile Early Warning System.

John M. Welch has been appointed director of field sales for the Aluminum division of Olin Mathieson Chemical Corp. He has been Chicago regional sales manager for Olin Aluminum.

William A. Ziebell has been named plant superintendent at Chicago Aerial Industries, Inc., manufacturers of avionic and reconnaissance systems and equipment.

Kevin O'Donnell has been appointed general sales manager at Steel Improvement & Forge Co., Cleveland.

G. D. Robertson has been appointed manager of the Advanced Development Engineering Department, Government and Industrial Division of the Magnavox Co., Fort Wayne, Ind. Since joining Magnavox in 1953, he has served as staff engineer, chief sonar engineer and section chief of communications and navigation.

Wesley L. Guiles has been named manager of Flexible Tubing Corp.'s Research, Development and Test Center at Guilford, Conn.

Murray Kanes, formerly head of the electromechanical development department of the Research Laboratories Division, Bendix Aviation Corp., has been appointed director of engineering of the Friez Instrument Division. **Dr. Lloyd G. Mundie** has been appointed by the Systems Division to direct a research program in the development of infrared projects.

Edwin A. Speakman, former vice president and general manager of Fairchild Engine and Airplane Corp.'s Guided Missile Division, has been named to the newly-created post of manager of planning for Defense Electronic Products, Radio Corporation of America. Speakman, who served for several years as Vice Chairman of the Research and Development Board, Department of Defense, will be responsible for analyzing military requirements, planning new programs and products, and coordinating short-and long-range planning for RCA's Defense Electronic Products.

Three senior members have been added to the staff of the newly formed Electronic Systems Division of Dalmo Victor Co.: **Arthur Hartman,** production superintendent, will be responsible for all phases of manufacturing, inspection, methods and test of electronic systems, test equipment and subassemblies; **Cmdr. Irwin R. Colldeweih** (USN, Ret.), engineering coordinator, with responsibilities for military liaison and provisioning; **Roark Talley,** senior electronics engineer in the Electronic Systems Division, which currently is working in the fields of sonar, magnetic detection, communications, countermeasures and infrared.

Arthur L. Munzig, Jr. has been appointed sales manager for the Commercial Division of Librascope, Inc., subsidiary of General Precision Equipment Corp. He will direct the sales and marketing activities of the Librascope commercial electronic and mechanical computer components.

Moscow briefs

• **Food For Men In Space Ships** is now being discussed by Russian experts. Soviet scientists are considering various ways and means of feeding men in hermetically sealed flying suits without opening these suits, including "possibilities of man's flight beyond the atmosphere." They are especially interested in feeding flyers from cans placed above the flyers' heads, through tubes leading from the cans to the vicinity of their mouths. Food items discussed include milk products and fruit juices, also liquefied meat having the consistency of a thick chocolate drink. Russian scientists also mention a specially prepared mixture of ham, cheese, and bread squeezed through a tube resembling a tooth-paste tube tightly fitted into the flyer's helmet.

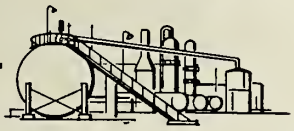
• **A Woman Test Flyer** has recently been glamorized and publicized by the Moscow press. She is Olga Yamshchikova, a jet test pilot and graduate of the Zhukovsky Air Academy. She holds the rank of lieutenant colonel in the engineering branch of the Soviet Air Force. Formerly, a combat flyer in World War II, she has a record of shooting down several Nazi planes in battle. After the war she became a test pilot, and has to date achieved much success in this specialty. She is married and has two daughters, the elder of whom is a student of chemical engineering. Though well along in years, Lt. Col. Yamshchikova is apparently slated for a yet more spectacular service, possibly for supersonic or space flying. In this connection it may be fitting to recall that last September, at a New York symposium of the American Psychological Association, a view was expressed that the first person to fly to the moon will be not only a Russian, but a woman.

• **As A Satellite Disintegrates,** precisely what happens to it? The problem of the satellite's status in its very last phase of existence is occupying Soviet scientists. Elaborate comparisons between falling meteorites and falling artificial satellites are on the Russian experts' agenda. The more we learn about the disintegration of such satellites, say V. Krasovsky and D. Okhotsimsky in PRAVDA, the better would we be able to understand meteorite phenomena "and use the latter for additional information about the upper atmosphere."

Because the shell of *Sputnik I* was made of aluminum alloys, it could not last longer than it did, these Russian authors say. They add that in the last

NOW Hamer Vented-Chest GATE VALVES

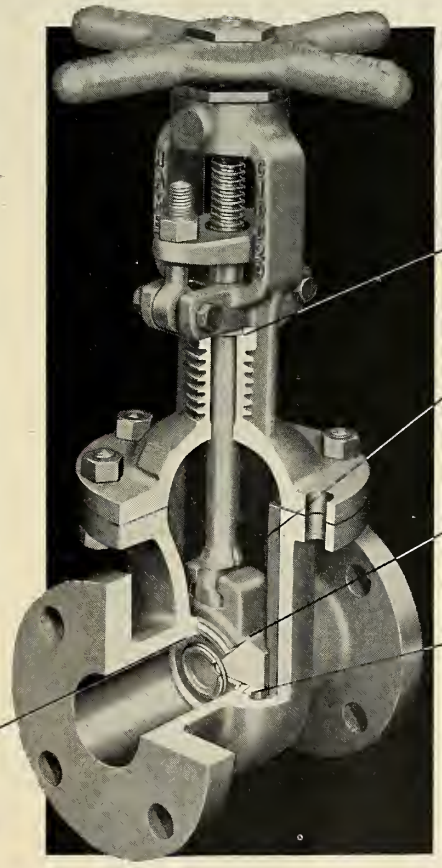
for Liquid Oxygen–



Hydrogen Peroxide Service

Safe, Vapor-Tight Shut-off of Hard to Handle Liquid Propellants . . .

Proven under actual environmental field conditions, these new Hamer "Vented-Chest" Gate Valves are contour engineered to provide smooth surfaces and clean lines without objectionable cavities where contaminating particles are often encountered. Seal in one side of wedge only vents chest of valve to pipeline eliminating possibility of pressure build up within the valve. Valves seal equally well with line flow in either direction. Air operated models available.



Integral Body Seat
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. . . Moscow briefs

stage of its existence *Sputnik I* passed over uninhabited parts of the Earth and often could not be observed properly because of cloudy skies. "We can hope," they write, "that *Sputnik II* and other subsequent artificial satellites would prove to be more observable in the last phases of their existence."

• **A Monument** to *Sputnik I* is being planned by the Soviets. A total of 100,000 rubles (nominally $25,000) has been appropriated by the government as prizes for the best memorial projects celebrating the launching. First prize is 30,000 rubles, second 20,000, and the third 10,000. The remaining 40,000 rubles are to be used by a jury as it sees fit, to encourage other deserving contestants.

The preferred form of the monument is an obelisk, although other sculptural or architectural suggestions may also be accepted. The role of the late Soviet rocket pioneer, Constantin Tsiolkovsky, should be reflected in the winning projects, according to the rules of the contest.

The monument will be erected in front of the skyscraper building of the University of Moscow in the Lenin Hills. May 10 is the closing date for the receipt of submitted projects.

• **Visual Observation of Artificial Satellites** is done in the Soviet Union from 70 stations attached to astronomical observatories, universities, and some teachers' colleges. These are manned by nearly 3,000 regular staff members and volunteer students. The results of observations are promptly telegraphed to "Moscow, Cosmos," which is the address of the central computing office. For visual observation of satellites, the Soviets also report their recent construction of "AT-1," a wide-angled portative telescope with a sixfold magnifying power. Each of the 70 watch-stations has 30 such telescopes. The staff of the Crimean Astrophysical Observatory of the Academy of Sciences is experimenting with the addition of a photo-electric eye to their "AT-1." The eye is a photo-element connected with a precise clock, to automatically register the moment of the satellite's passing.

In Washington, Dr. Richard W. Porter, chairman of the United States Earth Satellite Panel for IGY, estimated that it would take Soviet scientists eight to twelve months to decode and analyze the data collected by the two *Sputniks*. He said that he was "reasonably confident" the Russians would share such final results with

American and other Western scientists.

Studies have been going on at Gorki's Research Institute to find the influence of gravity on crystals according to m/r sources. Values for both surface energy and potential energy within the crystal reportedly have been derived and may be expected to yield valuable data for use in rocketry such as the improved orientation of metal crystals, improved physicals in solid propellants, and possibly for gravity "windows" or shields. The USSR has already stated that it is working on gravity propulsion systems.

Nikolai N. Semenov, noted physical chemist, is reported to be heading up free radical research at the Chemical Kinetics and Free Radical Laboratory in Moscow. Semenov, awarded the Nobel Prize in 1956 for his contributions to detonations, chain reactions, and combustion kinetics, is also Director of the Institute of Chemical Physics at Moscow.

There is now direct evidence that the USSR is producing large, extruded grains of ammonium-nitrate solid propellants. In addition to the earlier extensive studies openly published on the polymorphic phase changes, the N. S. Kurnakov Institute for General and Inorganic Chemistry at Moscow has now released its studies pertaining to the extrusion of ammonium nitrate.

I. A. Leskovich has stated that ammonium nitrate can be transformed into a metastable state with several times the plasticity of the more stable forms. More plastic forms would allow the use of high oxidizer loadings in solid propellants (and hence higher energy) or more compact extrusion equipment.

Atoms for space flight—Latest book out of Russia's Military Publishing House (Voyenizdat) includes a chapter on the possible future use of atomic energy for interplanetary flight. Authors of UTILIZATION OF ATOMIC MOTORS are G. N. Nesterenko, A. I. Sobolev and Y. N. Sushkov.

Red eye view—An article in SOVETSKAYA AVIATSIA gave special emphasis to the U.S. missiles, *Falcon* and *Genie*. Author M. Pavlov, a lieutenant colonel in the Russian engineering troops, notes that "employment of atomic warheads in the air-to-air missiles can considerably increase the effectiveness of fighter-interceptors against enemy aircraft carrying atomic weapons."

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. . . Moscow briefs

Reds—Soviet Journalist V. Ostrovsky, notes in LITERATURNAYA GAZETA that he recently flew over the island of Fernando de Noronha "where Americans have created their military base to experiment with guided missiles . . . thus attempting to violate the national sovereignty of Brazil." He expresses great satisfaction at Brazilian leftist protests against American use of the base to track missiles fired from Florida.

High-speed camera—SOVETSKAYA AVIATSIA terms "highly successful" recent Russian experiment with a camera capable of taking pictures in "millionths-parts of a second." Tests have included the recording of air bomb explosions.

Ghost Writer. KOMSOMOLS KOYE ZNAMIA, newspaper printed in central Russia, recently reversed itself on an announcement to reprint serially an old science fiction book by Alexander Beliayev. The Tambov paper said the author of THE STAR CALLED "KETS," "has decided to rewrite it; the reason being that the launching of the two *Sputnik*s and other latest achievements of Soviet science have corrected science-fiction predictions considerably." The article quoted the author as saying that he himself was going to rewrite the book. Author Beliayev died in 1952.

Writing in SOVETSKAYA ROSSIYA on the problem of returning a man to Earth from a space ship or a satellite, Prof. A. Shternfeld, well-known Russian rocket-and-missile expert, says that the use of a glider may prove to be the best means of such re-entry. He explains that a glider can be launched against the direction of orbit and can return to Earth on a slowing, semi-elliptical path.

This statement brings to mind the recently inaugurated Soviet experiments with T-4 and T-4A, rocket engines now being developed with a thrust of more than 800,000 pounds to 1 million pounds. This power is expected by the Soviets to launch a hypersonic bomber, send it to enormous heights and around the globe—then bring it back to its launching site *in a long glide.*

En route back, such a Soviet hypersonic bomber could unload nuclear-warhead bombs on practically any preselected target.

The difference between the two rocket engines is that T-4 is a test vehicle while T-4A is expected to be a vehicle in production, possibly by 1959.

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soviet affairs

by Dr. Albert Parry

Our Talk of Rocketing to the Moon before the Russians could get there has of course elicited a peevish Soviet reaction. Russian air experts now charge that the Pentagon is planning "the strategy of a massive blow against the countries of the Socialist camp by using nuclear weapons from bases on the Moon." In those lunar projects Americans are "sheer lunatics," says Capt. E. Fedulayev in SOVETSKAYA AVIATSIA. But, adds the captain rather reassuringly for his readers, these American plans are being spoiled by the very fact of the existence of the Soviet ICBM which (writes Fedulayev) "plays havoc with the aggressors' deck of cards and cools off their superheated heads."

Can Earth Targets Be Hit From Moon Bases? Only a few months ago the Soviet press ridiculed this notion. But now KRASNAYA ZVEZDA declares that rockets even smaller than ICBM can hit Earth targets from lunar bases. This possibility, the Soviet Army newspaper explains, stems from the Moon's weak gravitational force, being one-sixth that of the Earth. KRASNAYA ZVEZDA therefore suggests that any East-West agreements covering control of space-warfare should include provisions on rocket bases on the Moon.

As To Moscow's Own Moon Plans, neither of the two major Red projects of flights to or around that celestial body have been publicized by the Russians recently. Professor G. Chebotarev's famous Operation Boomerang is hardly mentioned these days.

The Khlebtsevich plan of sending an unmanned "tankette-laboratory" to land on the Moon appears to be under similar wraps. This silence may mean that the Russians are preparing to spring one or both of these projects as a surprise and a mighty propaganda gain.

However, most recently, Academician Anatoly Blagonravov did say: "The very next step in astrophysical development is a rocket flight to the Moon. This perhaps is not too far off." And another Russian rocket-and-missile expert, Professor N. A. Varvarov, announced that the problem of flight to the Moon can be solved "even if chemical fuel is used."

Lunar Temperatures have recently been discussed in Moscow. The Learned Council of the Chief Astronomical Observatory at Pulkovo revealed the results of the first scientific Soviet researches into the problem of measuring the temperatures of the Moon's surface. The main report spoke of the important observations made "with the aid of thermo-elements standing in the focus of mirror-telescopes."

A large radio-telescope was also used in these researches. The sharp gap between lunar temperatures in the course of a lunar day-and-night period, as compared with Earth temperatures within our 24-hour periods, was noted by Soviet scientists. They emphasized that "the deeper the pits or craters in the lunar surface, the less sharp is this change in temperatures."

The interest with which the Russians note this last-named circumstance may lead them to plan deep burrowing into the Moon's surface if and when they reach it. Their settlements on the Moon are almost certain to be underground.

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SPACE FLIGHT AND SATELLITE VEHICLES by R. B. Beard & A. C. Rotherham, 145 pp. $3.95, Pitman Publishing Corp., New York, Toronto, London.

The authors, who are members of the British Interplanetary Society, have assembled a kind of space primer for the "educated layman." The book encompasses recent developments and assesses imminent developments which will carry man into interplanetary flight.

Illustrated with 27 photographs and diagrams, subjects covered include basic principles of space flight, methods of achievement, our present position, proposed uses of satellite vehicles, and prospects for the immediate and far future.

The authors, through analysis of progress to date, project the space-flight question as far as 500 years ahead. Two space vehicles described as possibilities for interstellar travel by 2460 are the "deep freeze" craft and the "colony ship." The former, travelling at the speed approaching that of light, would operate automatically while the passengers' metabolism rate is slowed to the point where a journey lasting several years would age the travelers only several months.

The colony ship, moving more slowly, would accommodate a large number of people over a period covering several generations.

ROCKET POWER AND SPACE FLIGHT by G. Harry Stine, 180 pp. $3.75, Henry Holt and Company, New York

This book might be subtitled "Rocket Power Made Easy." Using simple analogies, the author explains the basic principles of building and launching rocket and space vehicles. The book evolved in answer to the letters to the author during his five years at the White Sands Proving Ground, where he was Viking-Aerobee Project Engineer and head of the Range Operations Division of the U.S. Naval Ordnance Missile Test Facility. Material from some of Stine's rocketry and space columns, which appeared in MECHANIX ILLUSTRATED, is included in expanded form. Stine writes in a "folksy" style which now and then erupts into dialog as he dramatizes some of the rocket launchings.

The book is well illustrated with diagrams and photographs.

The book includes a world roster of rocket, interplanetary and astronautical societies; major U.S. corporations engaged in rocket research and development; colleges and universities engaged in rocket and astronautical research

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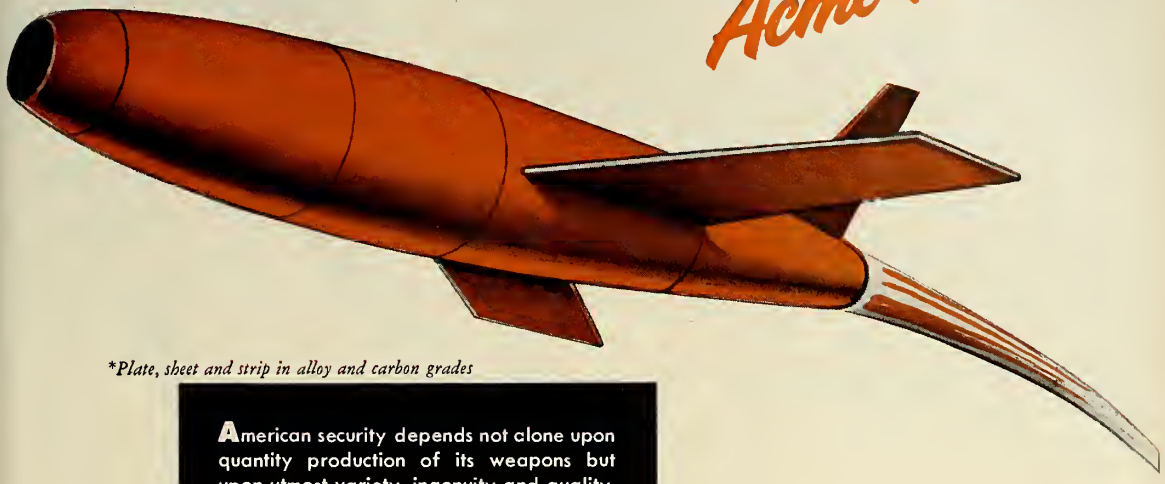

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and development; and U.S. guided missile test ranges.

It is an adequate book for the beginning engineer, providing a background in rocketry that is easy and quick to digest.

BOUNDARY LAYER EFFECTS IN AERODYNAMICS
National Physical Laboratory, Middlesex, England; $12, Philosophical Library, Inc., New York

Personnel engaged in aerodynamic research will find this volume of interest. The text is a collection of papers presented at a National Physical Laboratory symposium.

The papers deal with 50-year progress in the field of aerodynamics, and with problems of boundary layer flow.

The process of transition from laminar to turbulent flow is of particular interest; also of interest is the current knowledge of shock-wave and boundary layer interaction.

Other topics include three-dimensional boundary layers; the stability of flow over swept wings; profile drag calculation of two-dimensional aerofoils for supersonic speeds; and effects of shock-induced separations of turbulent boundary layers in transonic flow.

HIGH-SPEED AERODYNAMICS
by Prof. Elie Carafoli, 710 pp. $15, Pergamon Press, Inc., New York

High-speed aerodynamic phenomena, including both subsonic and supersonic flows, is presented in this English translation of the Romanian volume, AERODINAMICA VITEZLOR MARI.

The author gives a physico-mathematical introduction to simplify the presentation and to assure a readier understanding of several transformations. The fundamental problems of the flow of compressible fluids have been studied—with special emphasis on the speed of sound in establishing equations of motion.

The one-dimensional subsonic and supersonic flows in stream-tubes and nozzles is applied to wind tunnels. The book concentrates on the study of subsonic two-dimensional flows, and flows around bodies of revolution. The supersonic flows study includes analysis of two-dimensional and axial-symmetrical motion, both in the hypothesis of small disturbances and in the application of methods to practical problems.

SATELLITES AND SPACEFLIGHT
by Eric Burgess, 159 pp. $3.95, The Macmillan Company, New York

This prolific author (ROCKET PRO-

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Lockheed's F-104A Starfighter, newest weapon of the Air Force, is the most advanced airplane of its type. To give them the greatest possible resistance to extreme conditions, bearing surfaces *(arrows)* of hot air valves used in the F-104A are Flame-Plated with tungsten carbide. Flame-Plating provides the wear-resistant coating needed to withstand the high unit loading and temperature extremes jet plane parts undergo.

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PULSION, FRONTIER TO SPACE and GUIDED WEAPONS) gives added evidence to his ability to write in a popular vein and still give good technical treatment to a complex subject.

Burgess traces developments in military rocketry and earth satellites, and omitting needless explanation for readership popularity, discusses future methods whereby interplanetary flight might be achieved.

The book has good illustrations, but many have been outmoded since publishing date. The author comprehensively treats the many psychological and physiological problems of manned space flight, and the book will stand as good reference material. Rapid developments may require up-dating.

SIXTH SYMPOSIUM (INTERNATIONAL) ON COMBUSTION

by The Combustion Institute, 943 pp., $28, Reinhold Publishing Corp., New York

Some 200 authors from ten nations have presented papers on developments in the combustion field dealing with chemical, kinetic, aerodynamic, and thermodynamic aspects.

This collection of papers was presented at the Sixth International Combustion symposium. Subject matter includes structure and propagation of laminar and turbulent flames; high-speed reactions; flame stabilization in fast streams; instability in combustion chambers; ignition; combustion of explosives and solid propellants; evaporation and combustion of droplets and sprays; experimental and analytical combustion techniques and applications.

The book also includes panel discussions on future problems in research, high-speed reactions and flame stabilization in fast streams.

MATHEMATICS FOR SCIENCE AND ENGINEERING

by Philip L. Alger, 360 pp. $5.50, McGraw-Hill Book Company, Inc., New York

In this text, the author makes a complete revision of Charles P. Steinmet's ENGINEERING MATHEMATICS. Basic mathematical ideas are shown for their unity and simplicity, aiding students and engineers in using mathematics effectively.

Incorporating 80% of the mathematical procedures and methods needed in career engineering work, the book clearly explains methods and formulas. As a result, there will be little need for memorizing and less likelihood of misapplication of formulas.

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THERMAL STRESSES
by B. E. Gatewood, 232 pp. $7.50, McGraw-Hill Book Company, Inc., New York

Missile designers and analysts are constantly confronted with high-temperature problems. This book is the first on thermal stresses to cover all phases of the design problem at elevated temperatures.

Written for aeronautical engineers in particular, emphasis is on fundamental theory. This treatment is applicable to nuclear reactors, rocket motors, steam and gas turbines and guided missile structures, in addition to aircraft.

Topics discussed include temperature distribution; elastic and inelastic thermal stresses; combined applied and thermal stresses; allowable stresses of various materials at elevated temperature; and the buckling, deflection, stiffness, fatigue, shock, and flutter effects of elevated temperatures. Many recent advances in thermal stresses, temperature distributions, and material properties have been included.

Thermal stress calculation procedures developed are considered by the author as accurate as some other steps in the design sequence, and more accurate than temperature based on convective heat transfer calculations and the allowable compressive stress under creep conditions.

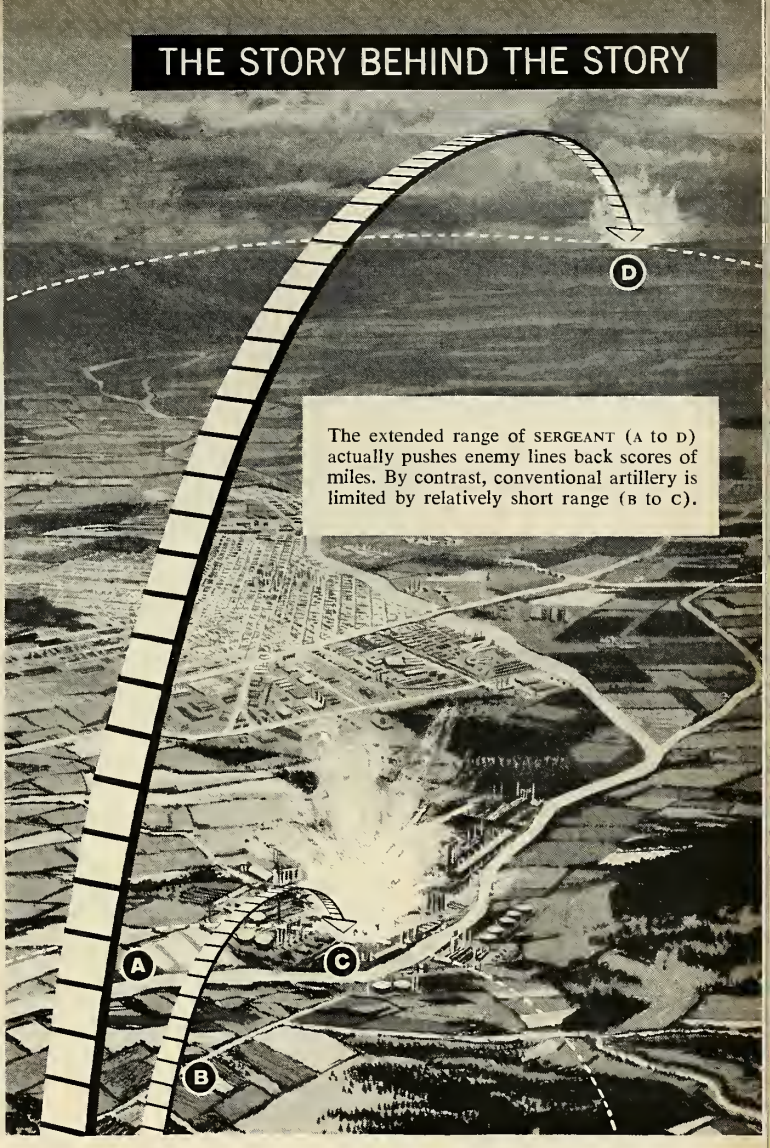
MAN-MADE MOONS
by Irving Adler, 128 pp., $2.95, The John Day Co., New York.

This is a small book which packs a lot of information from the launching of a satellite to the role the satellite will play as a prespace flight information gatherer.

In extremely simple language Adler covers and dissects what is now known of the earth's upper atmosphere and what we expect to learn by penetrating higher into its mysteries. MAN-MADE MOONS explains how satellites, the first artificial, will give man a more accurate picture of his planet: its shape, crust, surrounding atmosphere, solar and cosmic rays, the ionosphere, "earth-shine," the earth's magnetic field, to name a few.

The text is illustrated by some fine simplified drawings by Ruth Adler. The team of Adler & Adler have collaborated on six other scientific books, including HOW LIFE BEGAN, TIME IN YOUR LIFE, and THE STARS: STEPPING-STONES INTO SPACE.

In recent successful test shot, SERGEANT roars into ky. A ballistic guided missile, SERGEANT is guided for precision flight to target. New guidance system cannot be detected in operation.



The extended range of SERGEANT (A to D) actually pushes enemy lines back scores of miles. By contrast, conventional artillery is limited by relatively short range (B to C).

NEW SERGEANT MISSILE WILL GIVE U.S. ARMY GREATER STRIKING POWER

Development of the new SERGEANT ballistic guided missile is a timely reminder that our nation's security requires accurate, highly mobile tactical weapons for round defense as well as the more spectacular intercontinental missiles so much the news. In limited or global war, our frontline troops need the support of such weapon to crush an aggressor's attack ng before he comes within the limited nge of present artillery.

The SERGEANT missile is the answer... ready-to-go solid propellant weapon ith the ability to carry a nuclear warhead, a truly important contribution to the security and retaliatory power of our ground forces. In defense, the powerful SERGEANT will furnish U. S. Army commanders with mobile firepower that will be ready in minutes to strike at any attacking force. On offense, this highly accurate weapon can join tactical air units in destroying enemy fortifications.

The SERGEANT is being developed by the Jet Propulsion Laboratory of the California Institute of Technology for the Army. In preparation for production, Sperry has been working with JPL since the beginning stages of design and development. Complete production of the weapon system will be carried out by Sperry's Surface Armament Division.

Sperry's many contributions to the U.S. missile program, ranging from complete missiles to major sub-systems such as radars, automatic inertial guidance systems, electronic countermeasures, and automatic missile checkout systems, account for its selection as system manager for the production of SERGEANT.

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TV Guidance

Aircraft System May Be Applied To Missiles

Office of Naval Research's "Pathway in the Sky" system of TV-screen-presented instrumentation for high-performance aircraft, will definitely have application to manned space vehicles.

This "flying ribbon" concept, a development of the Army-Navy Instrumentation Program, started five years ago under sponsorship of ONR, BuAer and Army Signal Corps. The system will permit pilots to literally fly along a pathway displayed on a transparent TV-screen set into the cockpit windshield.

ONR says this type of instrumentation display would be required for reentry-type vehicles, such as the X-15.

The recently-unveiled system eliminates a pilot's need to read and interpret information from the clutter of dials in present cockpits. It gives him a three-dimensional presentation of the sky and ground.

Essential flight information—fuel consumption, flight plan, present position, destination and radio navigational data are programmed into a computer which gives a pictorial display.

For short penetration flights into nearby space, or even for short-time orbital flight, the system could furnish an invaluable reference to the pilot. It could link the thinking brain of its human operator to a space vehicle's automatic control system, furnishing information from great distances to allow time for decisions.

Such a pictorial display of information would have a tranquilizing effect on the pilot, for it would give him reasoning time for any changes in operational or environmental situations.

ONR estimates that approximately $15-million has been spent on this instrumentation program since its start five years ago.

No research funds have been particularly ear-marked for application to space-type vehicles, but ONR said such application is inevitable.

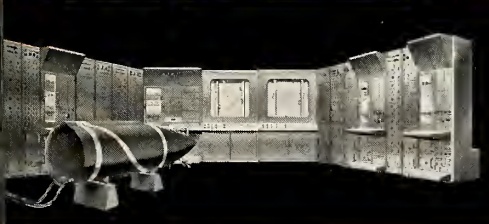
The El Segundo Division, Douglas Aircraft Company, Inc., is prime contractor and program coordinator for the program.

Douglas will have a space cabin mockup of the system at the Brussels World Fair. The Brussels display shows a guidance plane, bodies in space and a guidance path through these bodies.

The "Pathway in the Sky" display, including a thin television-type cathode ray tube which enables the display to be set into a cockpit window, was designed and developed by Kaiser Aircraft and Electronics Division.

Missile Trainer Simulators

Rheem Electronics has been engaged in the analysis, design, development, prototype manufacturing and production of missile and aircraft trainers and simulators since 1950. A wide range of technology has been developed in the electronic, optical and electro-mechanical field; servo systems/analog computer systems/closed circuit TV/radar and radar target simulation/flight platform simulation/optical projection systems/control and actuating mechanisms.



The test console depicts a typical simulation device utilized for the "dry run" of a missile and its components; significant advances have been made in the art of simulation to train personnel in missile operations.

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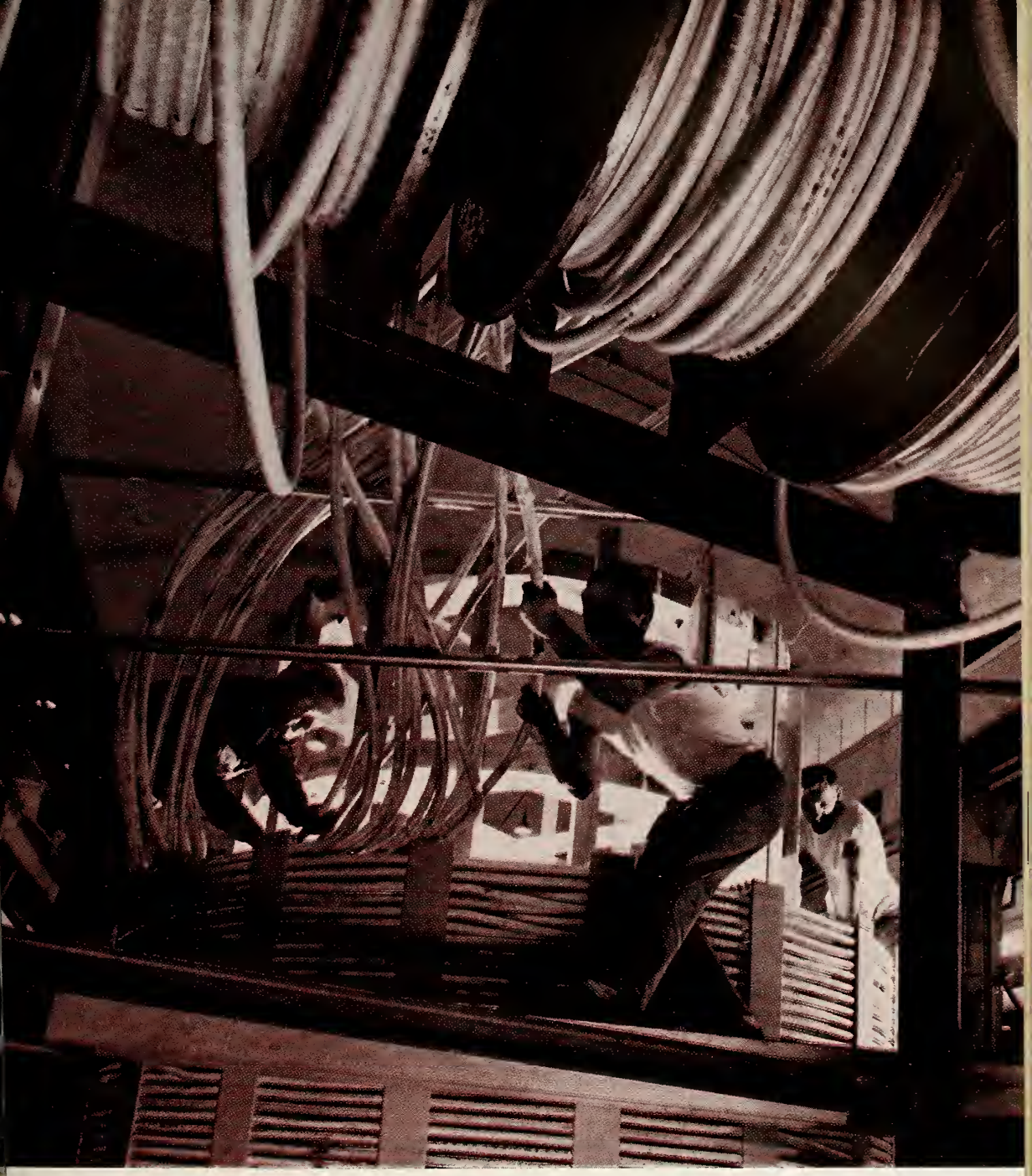

missile electronics

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MAY 1958

WHEN "MINUTES" COUNT

SYNCHRO FUNCTION	CPPC TYPE	PRIMARY Input Voltage (400~)	PRIMARY Input Current (Amps.)	PRIMARY Input Power (Watts)	PRIMARY Output Voltage (Volts)	PRIMARY Sensitivity (MV/deg.)	PRIMARY Phase Shift (deg. lead)	D.C. RESISTANCE Rotor (Ohms)	D.C. RESISTANCE Stator (Ohms)	IMPEDANCE Zro (Ohms)	IMPEDANCE Zso (Ohms)	IMPEDANCE Zrss (Ohms)	Max. Null Voltage (MV)	ACCURACY Max. Error (Min.)
Torque Transmitter	CGC-8 A-7	26	100	.5	11.8	206	8	37	12	54 ÷ j260	12 - j45	80 ÷ j20	30	7
Control Transformer	CTC-8 A 1	11.8	090	.2	23.5	410	9	150	24	212 - j684	22 - j115	246 - j60	30	7
Control Transformer	CTC-8 A 4	11.8	029	.08	22.5	390	8	389	64	560 - j1860	90 - j340	640 - j190	30	7
Torque Receiver	CRC-8 A-1	26	100	.5	11.8	206	8	37	12	54 - j260	12 ÷ j45	80 - j20	30	30 sp.
Electrical Resolver	CSC-8 A 1	26	038	.42	10.8	190	20	230	27	286 - j620	45 - j148	350 - j75	30	7
Electrical Resolver	CSC-8 A 4	26	038	42	26	454	20	230	170	286 - j620	250 - j830	350 - j75	30	7
Control Differential	COC-8 A 1	11.8	085	.21	11.8	206	9	36	25	38 - j122	27 - j120	48 ÷ j14	30	7
Vector Resolver	CVC-8 A 1	26	057	.34	11.8	206	10.2	78	27	103 - j440	8 ÷ j30		30	7

ACTUAL SIZE

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missile electronics vol. 1, no. 7

contents

missile electronic news

special features

New computer system speeds missile work. Packard-Bell Corp's TRICE computer combines features of both analog and digital techniques.

The TRICE, soon to be installed at the Army Ballistic Missile Agency's Computation Lab, is described by m/r editor Peer Fossen (p. 207).

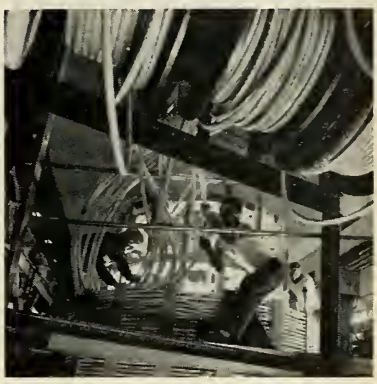
Thermistor speeds pre-launch check. Wider application of temperature-sensitive resistors seen.

R. L. Biesele, Jr., of Fenwal, Inc., discuss some aspects of thermistor applications in missiles (p. 213).

In-line relay cuts launching delays. A new answer to a constantly recurring problem.

m/r editor Raymond M. Nolan outlines features of a new relay concept where the relay actually becomes part of the missile cabling system (p. 219).

cover picture:



Pictured undergoing assembly is the world's largest inductance coil, which will permit research into many areas of astronautics and aerodynamics. Built by Westinghouse Electric Corp.'s Transformer Division, the coil will supply energy to an electric-arc tunnel for testing missiles in the Gas Dynamics Facility at the Arnold Engineering Development Center, Tullahoma, Tenn. The coil is similar to that used on a current-limiting reactor—except for the vast difference in size. A normal current-limiting reactor is wound with two or three 500-mcm cables; this coil is wound with 36 850-mcm cables in parallel. The coil is 119 inches in diameter, compared with 35 inches for a current-limiting reactor.

New extreme-high-temperature lubricants for missiles and supersonic aircraft **SHELL ETR GREASES**

One of the serious lubricating problems faced by designers of missiles and supersonic aircraft has been solved by scientists at Shell Research Laboratories.

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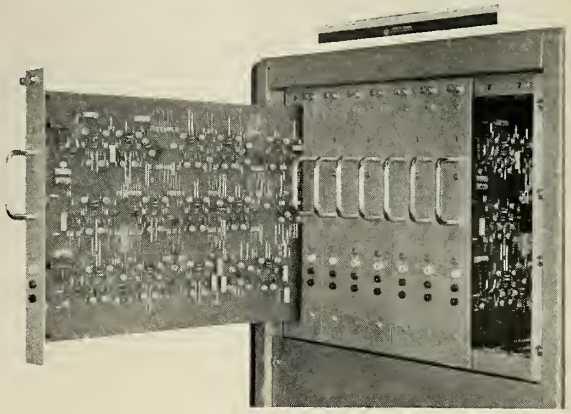
New Computer System Speeds Missile Work



by Peer Fossen

RAPID EXPANSION of the computer applications in missile technology has forced development of a new system combining both analog and digital techniques.

The new system is Packard-Bell Corp.'s TRICE (Transistorized Real-time Incremental Computer—Expansible). The concept of TRICE and its subsidiary equipment is a breakthrough in accuracy and speed for the control systems and calculations required by the race for space.

According to Packard-Bell, the TRICE will be placed in operation by the Army Ballistic Missile Agency's Computation Center at Redstone Arsenal this spring. A prototype system will be used to demonstrate the new digital techniques and acquaint personnel with the new concept.

The impetus for TRICE came from individuals with analog computer experience who felt that analog systems are not sufficiently accurate, especially when dealing with nonlinear systems. Other limitations encountered concerned difficulty in setting up complex problems involving many amplifiers and nonlinear equipment.

Although automatic setup equipment for analog computers has been available for some time, it is "hung on" rather than integral to the system. This equipment is largely electro-mechanical, whereas digital equipment is completely electronic.

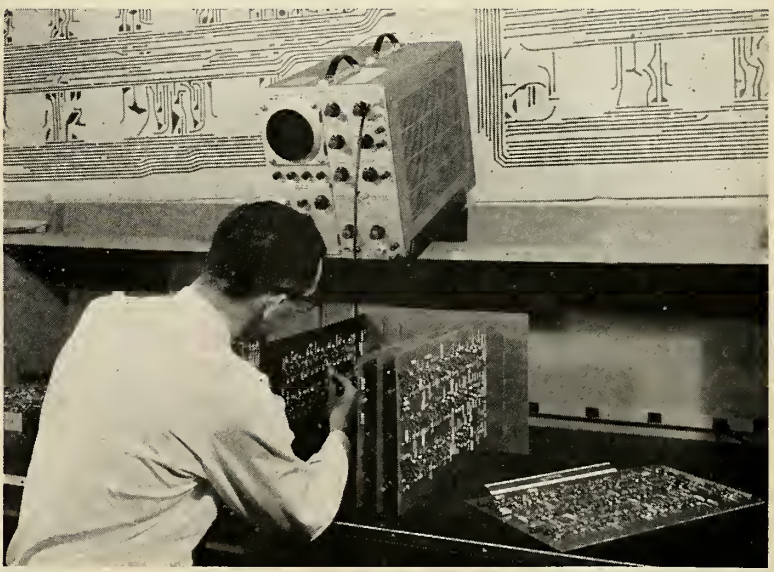
A first result of efforts to combine the two computer techniques, TRICE is claimed the fastest digital computer built. Operating at an iteration rate of 100,000 per second, the system combines the expansibility and ease of programming of analog computers, with the precision and repeatability of digital computers—at a speed that makes possible real-time digital solutions of such problems as missile simulation flight.

• **Basic elements**—The TRICE computing elements are basically five in number: three incremental computer building blocks, a digital function generator and an analog-to-digital, digital-to-analog conversion system. All are completely transistorized.

The three incremental computer blocks are an integrator, a multiplier and a digital servo. The integrator is similar to integrators in existant serial digital differential analyzers but with important differences. First, it is physically independent as are the amplifiers of an analog computer. Secondly, it operates at very high speed; will integrate a given variable with another variable—not necessarily time—100,000 times per second.

It is difficult to compare digital computing speeds with analog responses, but, roughly, this integration rate corresponds from 10 to 20 cycles. Lack of restrictions on the independent variable generates both linear and nonlinear functions by the same computing element.

Integrators employ an integration formula and an intercommunication scheme that minimize errors for parallel digital computation. The quadrature formula employed is a modification of the extrapolative form of trapezoidal



All photos by donn maur.

FIG. 2. Technician checks plug-in modules prior to assembly on plug-board.

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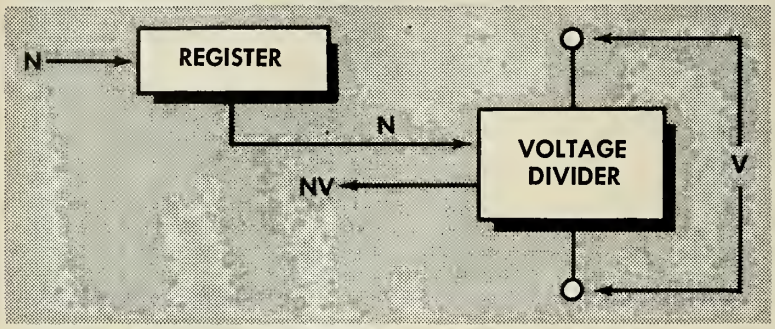

FIG. 3. Digitally-controlled voltage divider unit of the MULTIVERTER.

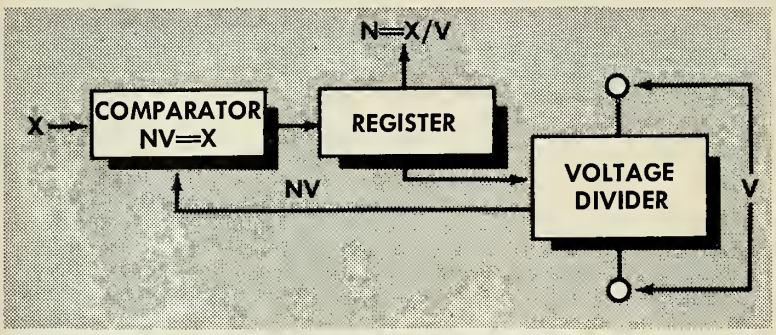

FIG. 4. Bi-directional counter used in the analog-to-digital converter.

integration. This not only provides a second-order correction, but partially corrects the time lag introduced by the parallel mode of operation. The interconnection scheme makes it possible for the information interchanged among computing elements to have three values: +1, 0 and —1.

In operation, stable sine waves of several hundred cycles have been generated.

The basic integration unit can generate both linear and nonlinear functions. For convenience, a multiplier unit has been developed. This generates increments of the product of two functions, given the two functions in incremental form. This unit also operates 100,000 times per second and yields exact products.

The third element is a digital servo. This unit generates inverse functions such as square roots, arcsines, etc. It may be thought of as the digital analog of a high-gain amplifier that produces a maximum output for any magnitude input error signal. Resolvers and other special elements probably will be constructed. While subject to truncation and round-off errors, the TRICE, being digital, is not subject to drift, and can be employed to solve real-time problems that, like certain trajectory calculations, require long computation.

• **How it works**—These three elements theoretically are sufficient to generate any analytical functions produced by an electronic analog computer. Because of cost and other considerations, this equipment can generate one or several of the loops in a problem while standard analog equipment is used to generate the remainder. In this case, a conversion system is required to transfer information between the two computers.

The first requirement of such a conversion system is high accuracy—0.01% of full-scale. This full-scale accuracy is particularly needed if small values are to retain a reasonable degree of accuracy.

The other requirement is a 10-microsecond conversion time. An incremental converter can be used here since the amount of information that must be transferred over each channel precludes multiplexing a single converter among many other variables. An incremental converter is one where a bi-directional counter follows the input wave form. The limitation of this device is the same as the computer—it can change by 100,000 increments per second with no reduction in frequency response.

• **Conversion System**—Packard-Bell also has developed a novel conversion system, the MULTIVERTER. Heart of the system is the digitally-controlled voltage divider shown in Fig. 3.

Given a number, N, and a voltage, V, this device will generate NV so that in going from a digital computer loop to an analog loop, a multiplication can be performed with an accuracy of 0.01%.

If this voltage divider is employed to provide comparison voltage into a comparator, and causes the bi-directional counter to go up or down, the result (as shown in Fig. 4) would be an analog-to-digital converter.

The comparator, in this case, compares the input voltage, X, to the output of the digital voltage divider, NV. The counter is changed to make these quantities equal; hence. X = NV or N = X/V. This means, in going from an analog loop to a digital loop, that the conversion system will generate the digital value of the quotient of two of the analog variables. The converter's incremental outputs are at the central plug-board and are completely homogeneous with the incremental signals generated in the computer proper.

• **Functional generator**—The final component is a digital function generator.

Photographic techniques store the values of the independent and dependent variables on a small strip of film.

Several methods are variable for operating upon the values as they are read. The most straightforward is to store the dependent variable incrementally so values can be treated the same as the incremental outputs of the computer elements and the conversion system. Limitation is that the function can vary only a small number of increments for each stop of the independent variable.

In certain cases, the arbitrary function has abrupt steps or other discontinuities. For this reason a function generator supplies the value of a function for a given argument rather than incremental values.

Being a mechanical device, the function generator cannot supply 100,000 new values per second. For many tasks, this high speed is not required, but in some cases new values of the dependent variable must be supplied as a rate almost as high as the iteration rate.

In these cases, the number stored is the first or some higher difference. By employing one or several integrators, this difference value can generate functional values at the required rate, although the difference value changes relatively slowly. A similar system for analog computers is also under design.

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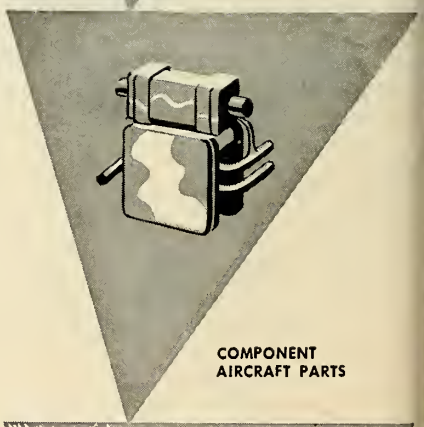

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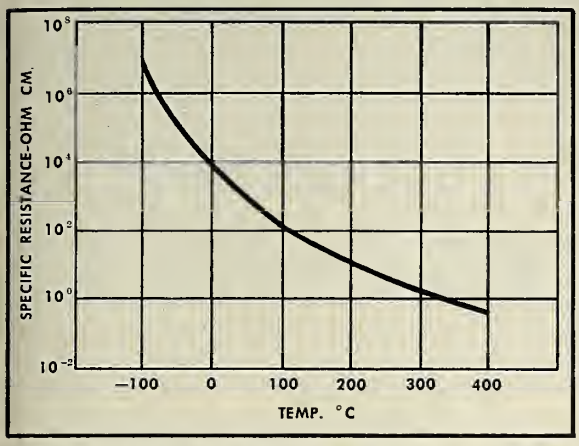
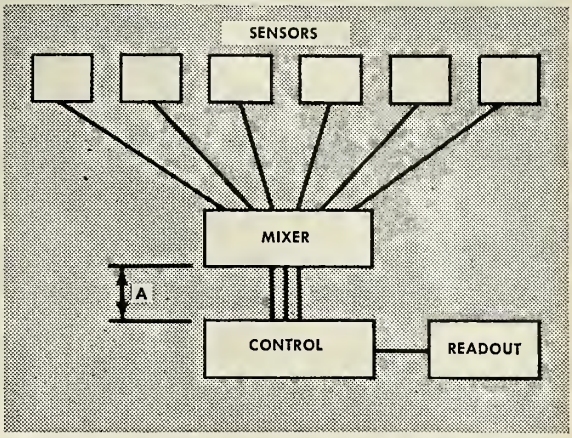


RESISTANCE-TEMPERATURE characteristic of a typical thermistor. Note particularly the large resistance change for relatively small temperature changes.



SCHEMATIC of typical thermistor system for missile ground check-out. Sensors and mixer are installed on missile, other components on ground. Distance "A" can be 250 feet or more.

Thermistor Speeds Pre-Launch Check

by R. L. Biesele, Jr.*

THE MOST IMPORTANT element in missile operation is temperature. It is an, ever-present consideration in selection of material for construction, and is equally important to the operation of equipment used on the missile.

To provide a definitive listing of all the temperature considerations in missiles is extremely difficult, so this article is concerned only with a system concept that is applicable to ground check-out of temperature.

Two general areas are involved: storage of the missile to insure that it is both safe for personnel and in a high degree of readiness; check-out during the immediate pre-firing period, or countdown.

During the countdown, temperature check-outs not only determine the operability of the missile, but are also used as controls on certain parts. An example would be the air conditioning equipment used to hold various sections of the missile at specified temperatures. Ground control equipment can be used for this function: once the missile has been fired, its flight time is sufficiently short so that, with proper equipment design, no serious temperature variations will occur.

An important area of ground check-out is the engine, which must be warm enough to insure that valves do not stick, and that other components operate at maximum efficiency. This problem is complicated by liquid fuels, such as liquid oxygen, which involve extremely low temperature, and by the wide varieties of climates in which the missile may be used.

Communication equipment also requires temperature check-out. Crystals, transistors, and many other electronic components change value significantly with temperature variation.

The guidance system is the most important area of temperature control. All inertial guidance systems have precise temperature control built in to maintain operability throughout the missile's flight. During count-down, all systems must be checked to ascertain that they are within specified temperature limits.

• **What's a Thermistor?**—Obviously, any type of temperature measuring device can be considered for check-out, and, in fact, many types are used. Miniature thermal switches are commonly used on the missile itself. Thermocouples, resistance bulbs, and many others also find their places.

One type of temperature measuring system that is gaining wider application and usefulness is based on thermistors.

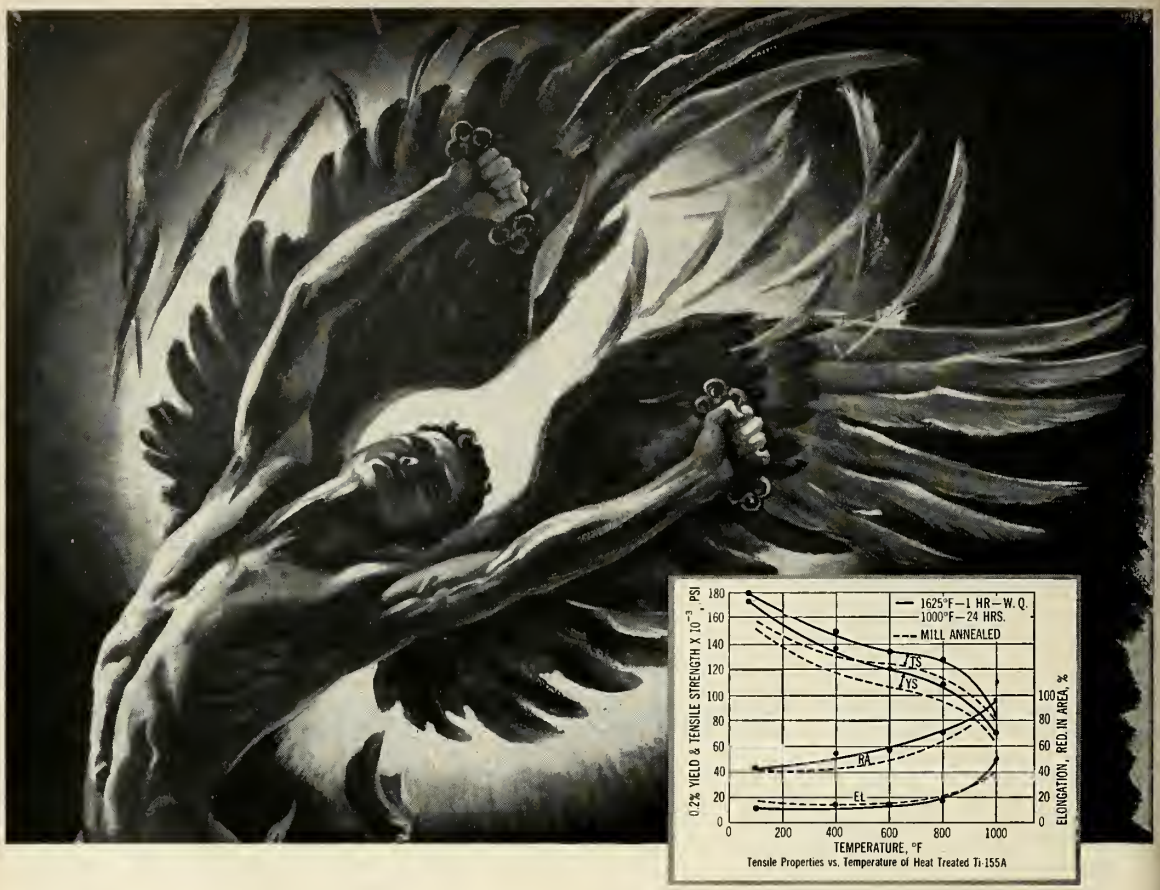
A thermistor is no more than a temperature-sensitive resistor which has a negative temperature coefficient of resistance. This characteristic, which is fixed, predictable and stable, is illustrated in the accompanying graph.

In missiles, thermistor systems include sensing probes, which are the thermistors themselves, a mixer to consolidate information from several probes, a control unit to interpret this intelligence, and a read-out (diagram).

Missile check-out systems must have, among other specific characteristics intrinsic to the application, full consideration of reliability, speed, accuracy, simplicity, weight, size, and, of course, cost. These apply to any system, and are not peculiar to thermistors. Nevertheless thermistor systems should be analyzed in terms of these broad considerations:

Reliability—Here the need is not only for the reliability of the system itself, but the reliability of the information it provides. A check-out system which compounds the complexity of

*Project Supervisor, Electronic Design Fenwal Incorporated, Ashland, Mass.



Tensile Properties vs. Temperature of Heat Treated Ti-155A

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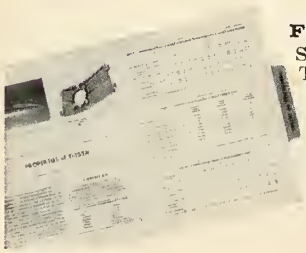

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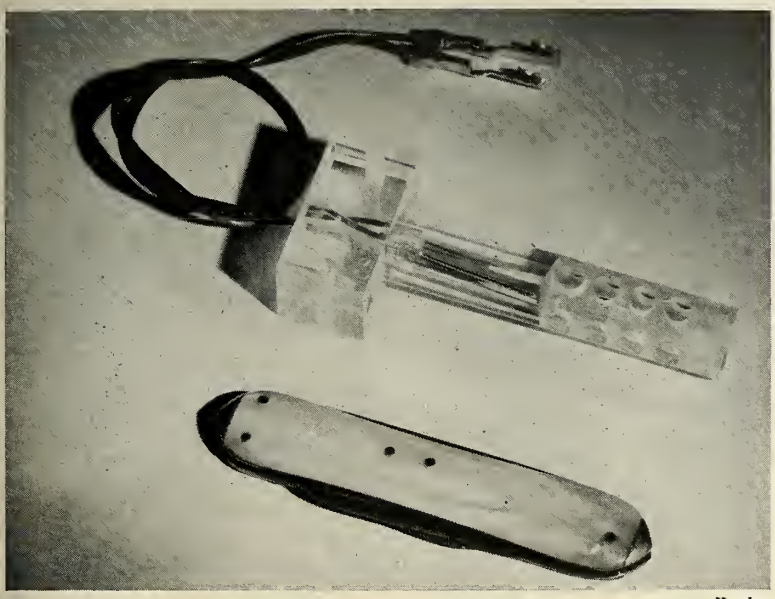

Korday

TYPICAL thermistor probe used in missiles. Thermistor is encased in plastic, and housing is perforated to permit fast response. Pocket knife gives size comparison.

the weapons system is an absurdity. Thermistor systems offer many advantages in this area.

First is the fact that thermistors are among the very few electronic components that do not depreciate with age.

It will be noted, too, (on the graph) that there is a large change in resistance for a small change in temperature. This means that a thermistor has a large "signal" output, particularly in comparison with such devices as thermocouples.

The large signal permits simplified associated circuitry; extensive amplification is not required, nor are extremely sensitive relays. In fact, under certain circumstances, both amplifiers and relays can be eliminated, making possible a system without moving parts and with consequent increases in reliability of action.

The high "signal" also produces simplified wiring. Not only does the mixer consolidate information and thus reduce wiring, but the number of connectors required is substantially reduced as compared to other design approaches used.

Accuracy—This is a corollary of reliability, yet it also implies the ability to detect minute temperature changes—of particular importance where the temperature is critical and a tiny variation can have serious effects on missile performance. In addition to the large resistance change for a small temperature change, which makes the thermistor more sensitive than many other types of sensing elements, there must be added the small size of the thermistor—they can be made the size of a fly speck—which means a low thermal mass that is extremely responsive to environmental changes.

Obviously, accurate readings are not only necessary to control to the close tolerances required in missiles. They are essential so that the transmitted information becomes sufficiently meaningful to produce proper corrective action.

Speed—A major problem is to activate the "bird" as quickly as possible after the command has been given. To the temperature check-out system, this means that the information sensed must be transmitted virtually instantaneously, and that there must be a maximum of time allowed for corrective action where necessary.

For this, the thermistor provides inherent technological advantages. First, the system is completely electronic and independent of any mechanical linkages. It does not require tubes of any kind and eliminates the essential warm-up period such components require. Thermistors are small and can react virtually instantaneously.

With respect to speed, many missile

thermistor systems are designed to provide passive, continuous check-out. In these cases, the system is operating at all times and automatically signals whenever a fault occurs.

Weight—It has long been a rule of thumb that in a large missile, each pound saved adds one mile greater range. Conversely, it is also important to have ground equipment as light and portable as possible, for maneuverability and transportation. Insofar as the missile itself is concerned, the probes that would be mounted thereon can thus be fly-speck size, with a weight that is measured in milligrams. Furthermore, by mounting the mixer on the missile, the weight of necessary wiring is also substantially reduced.

But what of the ground equipment? Here, the weight will be a function of the amount of information desired. If recorders, analyzers, and similar equipment are needed, the weight will be proportionately greater. However, the nature of the thermistor, its high signal output, less need for extensive wiring, amplifiers and relays—all will aid materially in keeping weight—and size—of ground equipment within manageable proportions.

Size—In the vast reaches of outer space, space is at a premium. This paradox is a major problem for the designer, that could be solved by the small size of thermistors and their associated control units.

Cost—As every engineer knows, there is no such thing as "Damn the cost." In missile check-out systems—as in all other equipment—cost consists of two elements: the material cost of the unit itself and the cost of designing or engineering a particular system.

We can dismiss the former very quickly, for actual material cost is but a small part of the total for a thermistor system or any of the alternative approaches. However, it can be stated that thermistors can often be made for much less than other temperature-sensing devices with applicability.

Nevertheless, it is the engineering costs we must consider. Since missile requirements are so often for one or two units for prototype testing, or the actual production quantity is not in the realm of so-called "mass production," engineering charges that would otherwise be amortized become very significant.

Here a thermistor system offers fundamental advantages. First, the overall concept of its operation is rela-

tively simple, in the complex of missiles.

The elements of this diagram are common to every system; the design problem is to tailor each to the specific nature of the application.

It is of relatively little importance in the design, for example, whether a system has 10 or 50 sensing elements. The thermistor sensor itself can be easily adapted into nearly any desired configuration. Control, mixing and read-out components can be grouped into a few interrelated designs which, by choosing the desired combination, can be adapted to virtually any requirement. In view of these factors, engineering costs on thermistor systems can be proportionately less than for other systems that may vary substantially with the application.

• **Typical System**—Let us look at a typical general thermistor system, consisting of sensing elements—the thermistors, a mixing network, a control unit, and a read-out. Such a scheme is shown in the block diagram.

Sensors are mounted at those points within the missile upon which a temperature check is desired. Each sensor is, in turn, connected with a mixer through the simplified wiring discussed previously. The mixer, which consolidates the information from several sensors, is also generally mounted on the missile and is expendable upon firing. Such mounting is particularly desirable since it cuts down on the number of wires running out of the missile, and significantly shortens their length and cost.

Though several sensors may feed information into the mixer, only three wires are needed to connect it to the control unit, which is located on the ground.

The control, which translates the information received from the sensors, can be designed to accomplish a number of functions.

The control unit, in turn, actuates the read-out; the type of read-out used being, naturally, a function of the overall system requirements.

Systems incorporating many of the principles described here are now being actively considered by many missile engineers.

Interestingly, the general capability of monitor systems is not limited exclusively to temperature control. It can, with reasonable effort, be extended to include pressure, acceleration, voltage, or any other parameter which can be translated into voltage.

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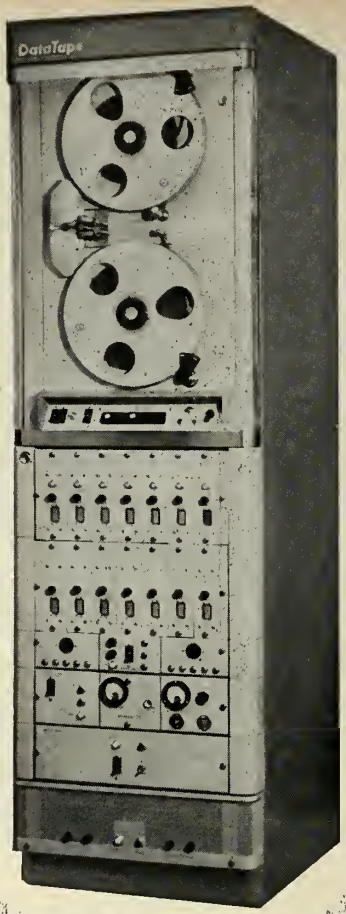

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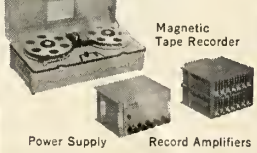

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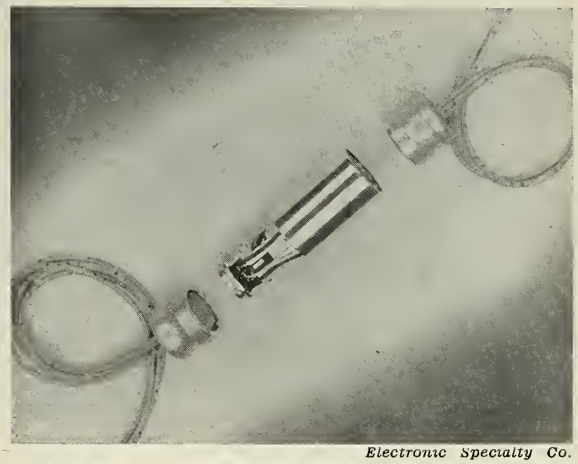
Countdowns can be halted by failure of any of countless tiny mechanisms. Here's a new device that may save time and trouble . . .



Electronic Specialty Co.

CABLE ENDS are hermetically sealed into locking connectors which carry complete static and dynamic loads on the relay. Cover is protective only, carries no load.

In-Line Relay Cuts Launching Delays

by Raymond M. Nolan

COUNTDOWNS in big missile shoots oday are, at best, a trying and frus- rating experience.

Time after time a halt must be alled because of the failure of some rosaic component such as a relay or valve.

Most solutions center around metic- lous checking of each tiny part be- re the countdown begins. But if fail- re occurs after the pre-firing pro- edures are in progress, nothing can e done except trouble-shooting and eplacement of faulty components.

Electrical relays are especially sus- eptible to such failure and to another ven more important trouble—failure flight. Much work is currently being one to improve this situation. Oc- asionally an idea which can truly be alled a breakthrough becomes a eality.

Something new in this line was re- ealed recently—an in-line relay with ll cables connected axially and the nit suspended directly in the cable un.

This new device, developed by lectronic Specialty Co., Los Angeles, alifornia, promises to alleviate—if ot abolish—most of the difficulties hat are now encountered in missiles ith relays.

The in-line relay may be placed nywhere in the missile cable runs. is supported by the cables themselves and therefore virtually immune to shock and vibration. Damping effect of the cable mounting is so complete, that no measureable motion of the relay is registered when the cable ends are vibrated through the complete frequency range outlined by Mil Specs.

• **Tiny and tough enough?**—Missile guidance and control today is dependent on literally hundreds of relays to perform essential sequencing of electrical operations. Since the switching function is performed by closing a gap as small as 0.05-in., it is clear that these units must be rugged and reliable if accidental tripping due to vibration, shock, arcing or high-temperature expansion is to be avoided.

Traditionally, these dangers are met by grouping the relays in relay control boxes and mounting them rigidly to the airframe; but increasing missile speeds and altitudes are rapidly outmoding such a solution. One example is the skin friction heating generated by supersonic speed. These temperatures are transferred through the structure into the relay and are now handled only by the use of high-temperature materials and forced cooling of the components.

Another problem in control is the marked reduction in air density as missile operating altitudes are progressively increased.

This results in rapid loss of insulating properties of the atmosphere in the relay terminal gaps with ultimate arcing across the gaps, even when hermetic sealing is used.

The progress in miniaturization made by the relay industry over the past decade has created tiny units that weigh only a few ounces and occupy less than a cubic inch of space. But this miniaturization has meant shrinkage of the distance between terminals with accompanying corona discharge and arcing risks.

In the in-line relay, the high potential difference between the power cable ends controlled by the relay is separated at opposite ends of the unit, providing the maximum possible protection against arcing and corona discharge. This arrangement also reduces the effect of stray capacitance and other residual electrical properties that plague single-end relays.

• **New answer**—The new "straight-through" relay design, subject of a military specification to be issued shortly and covered by recently-awarded Patent No. 2,825,782, avoids most of the difficulties mentioned above.

The new unit is, essentially, a conventional sub-miniature relay of tested and proved specification performance, but secured in a radical new mounting.

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Electronic Specialty Co.

IN-LINE RELAY is mounted in the wire bundle, anywhere within the missile and thereby isolated from structural heat or vibration-transfer into its interior.

While the conventional single-end relay mounting produces a sunburst of wiring in which the relay is the fulcrum of a tug-of-war, the new design makes obsolete the connection problem by routing all input wiring into one end and bringing all output wiring out the other end.

The fact that the new relay can be freely mounted virtually anywhere with the missile structure, opens many new design concepts for the engineer. In most cases, it will no longer be necessary to run high-powered cable through large connectors into pressurized areas for such purposes as protective circuit-breaker reset. Instead, the remotely-located circuit-breaker can be reset by a slave in-line relay actuated by a small control line.

The in-line relay can be located inside access doors situated for other purposes, for example, and requires no brackets or clamps for securing.

• **Eases repair**—Trouble-shooting—and especially trouble-shooting during countdown—in missiles has multiplied in difficulty with the increase in electrical complexity and much of this maintenance burden involves the search for faulty relays in a maze of relay wiring.

In some cases, literally hundreds of wires pass through a relay control box. The rapid and correct identification of individual wires tests the capacity of maintenance personnel in addition to wasting precious time prior to missile firing.

However, maintenance of in-line relay-equipped missiles would only require the mechanic to break out the wire bundle and replace the relay with two twists of the wrist, instead of the currently-required backing off of nuts and their replacement in cramped quarters.

The installation completely eliminates mounting brackets with an attendant decrease in weight. Merely multiply the saving in weight by the number of units in an average large-size missile—this factor alone makes installation of in-line relays worthwhile.

This promising development shows an interesting new trend by adding a new duty to a component (supplying its own mounting function) rather than the usual search for means of taking away duties performed by a functional unit.

The new Electronic Specialty in-line relay literally carries its own weight in performing its function in missile electrical systems, and, in one simple revision of a classic concept, eliminates or drastically alleviates the frustrating difficulties of the environment-prone relay—the largest family of electrical units in service today.

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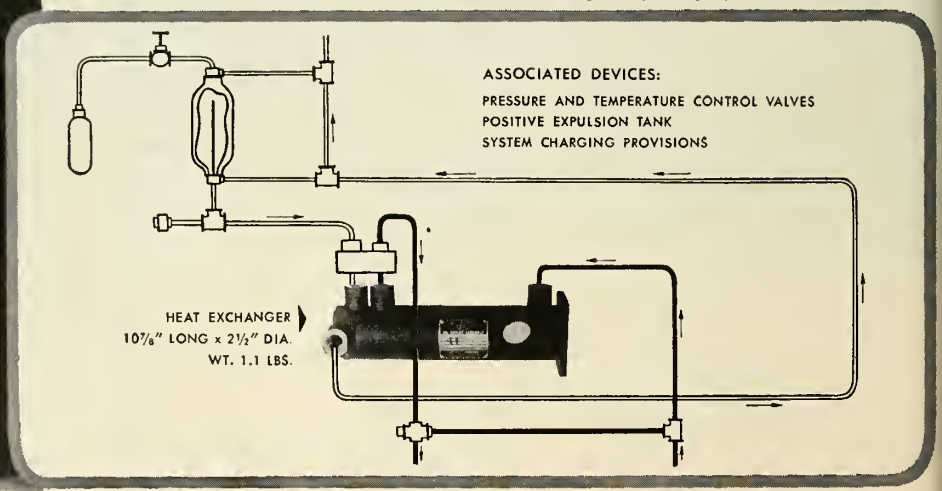

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Titan Guidance Program is Accelerated

USAF's most sophisticated system draws near operational status as manufacturer expands

by Raymond L. Nolan

Production of what is probably the world's most sophisticated inertial guidance system is currently being accelerated by a large-scale expansion program underway at the Arma division of American Bosch Arma Corporation.

Parts of the *Titan* guidance and control system—originally scheduled for manufacture at the old Studebaker plant at Midway Airport in Chicago—are now being manufactured in Long Island.

Arma is leasing space in Hicksville, L.I. at the present, but has added 20,000 sq. ft. of space at its Roosevelt Field location recently and indications are that more space will be provided as needed.

• **Transfer helps**—This transfer of the program from Chicago has placed Arma in a favorable position compared to most other Long Island manufacturing companies, which are definitely feeling the pinch caused by stretchout of their respective programs. In round figures, Arma employed 4,800 people prior to the stretchout, reduced to 4,500 before transfer of Chicago operations, and currently has 5,100 people on the payroll.

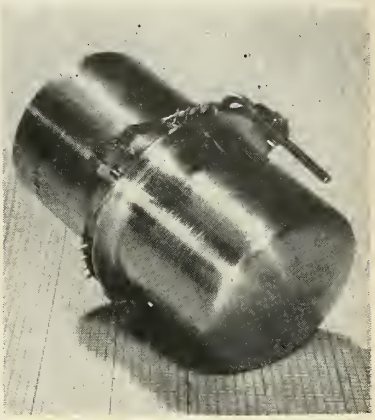
Just how many of these people are actually connected with the *Titan* program is difficult to estimate, because of the intermingling of the B-52 tail turret work with the *Titan* work. However, all of the expansion is for *Titan* alone.

One phase of the expansion is the addition of a third "sterile" room for assembly of gyroscopes and accelerometers.

Projects now underway include the installation of new air-conditioning, a vacuum system for the sterile room, insulated walls, drop ceiling, and tile floors. In fact, for really critical operations, there are "sterile areas" within the "sterile" room where only the hands of the assembler get near the hardware.

Equipment is being installed in the roow now, although there is no time set for its use. The first two "sterile" rooms are off limits for security reasons, but the new room has provision for around 70 production workers, so this probably places the number of people in gyro and accelerometer assembly at somewhere between 150 and 200. Add to this the 1,000-odd engineers and other production and test workers for the normally-assembled parts of the guidance system and the spending level probably reaches something like $55 or $60 million per year.

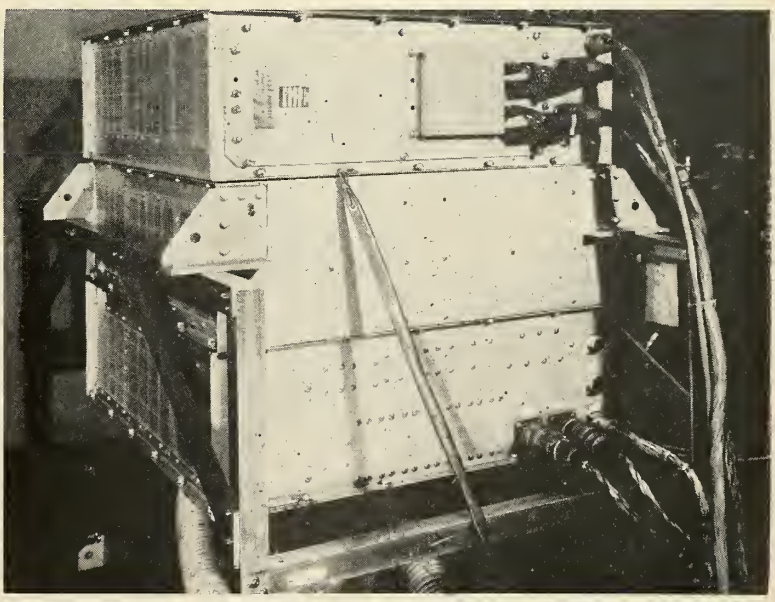
This figure is in line with AF Ballistic Missiles Division's chief, General Schriever's recent statement that the entire *Titan* guidance program from inception through presently-ordered production units totals $140 millions. Approximately $51,000,000 of the funds have been expended through the 15th of March, 1958, with the remainder reflected in the Company's backlog of military orders, currently estimated at $165 million.



VIBRATING-WIRE type accelerometer used in the *Titan* Guidance and Control System. Two such units are used to measure range and lateral deviation from course.

• **Guidance details**—Although details of the *Titan* guidance system are still classified, enough information has been released to define the system in a general way.

Basically, the Arma guidance and control system comprises a Control



GUIDANCE COMPUTER from *Titan* System. Unit is assembled in three decks and uses group of 6 x 9 in. circuit cards. Germanium semi-conductors are used throughout. Redundant connections make the possibility of failure from wiring failures remote.

Central, a Guidance Computer and a stable platform with two gyroscopes and three accelerometers. Information about the Minneapolis-Honeywell elements of the guidance and control system has never been revealed, but M-H seems to be connected to the pitch programming, engine control, and in-flight stability problems of *Titan* guidance and control.

The control central feeds servo power, temperature monitoring and other control functions to the inertial platform.

The digital guidance computer produces control signals from received and stored information, to keep the missile on course, and provides engine cutoff signals to the sustainer and vernier engines. The guidance computer is assembled into three decks and occupies a two-foot square, about two feet deep.

All the circuitry is built around solid-state elements and assembled onto 6x9-inch cards which are then encapsulated. Germanium transistors are used throughout. Almost 1,000 are used for the complete computer.

Redundant connections are used throughout to lessen the possibility of failure under missile flight conditions.

While the primary purpose of the guidance computer is to solve the cutoff equations for sustainer and vernier engine cutoff, it also includes the pitch programming device with some sort of a hook-up to the Minneapolis-Honeywell elements of the guidance system. This unit is a diode matrix and can store information for a total of four targets. If the target selected should not be one of the four, the unit must be removed and another one installed, not a difficult operation as Arma has provided for quick removal.

Other guidance systems, such as the *Jupiter*, make use of magnetic tapes which must be changed in accordance with the target so the relative inflexibility is not unique with the *Titan*.

• **Future development**—Arma's future plans for the guidance computer are interesting—a two-stage program is designed to reduce the weight from the present weight to "something really small," in the words of one Arma engineer.

First phase of this program involves sandwich construction with silicon elements and new standard 1/10th watt resistors and will result in a reduced size package. Ultimate goal will be realized with ultra-small ceramic wafers (1x1 inch) now being developed by the Diamond Ordnance Fuze Labs in Washington.

Another element to be miniaturized and made lighter is the quartz delay line which will be replaced with a magnetostrictive delay line. Plan is to install the new delay line around the periphery of the units and use the empty center for assembly of the ceramic wafers. No time estimate was given for the ultimate package, but Arma engineers hope to have the interim unit in about two years.

Information about the stabilized platform is still in the security area, but some details of the gyros and accelerometers was released. A platform outer shell was shown at the IRE show in March and appeared to be about half the size of the *Thor* unit described in the March issue of m/r.

The stabilizing gyros are two-degree of freedom, torsion-wire suspended, fluid floated unit. The fact that each has two measuring axes means that only two gyros are necessary. As in most gyros used in inertial navigation, the spinning element is a motor, and power is brought in through the torsion wires.

Pickoff devices are mounted on the motor shell and on the outer shell. Coincidence of their positions results in a stabilization servo loop null and keeps the gyro in proper orientation. The accelerometers are non-gyroscopic, and use a unique approach whose description still falls in the security area.

CONTROL CENTRAL unit from the *Titan* guidance system. This piece of equipment, like others in system, are manufactured by Arma division of American Bosch Arma Corp.

HEART of the *Titan* guidance system—the two-degree of freedom, torsion-wire suspended, fluid-floated gyroscope. Two gyros provide the reference system for inertial measurements.

• **Super test lab**—The combined development and production test gyro laboratory where the gyros undergo final inspection and calibration prior to assembly on the platform is, in the words of an Arma engineer, "one of the largest and best equipped labs of its type on the east coast."

The dominant feature of the room is a group of six Fecker Co. sidereal tables. The stands are mounted on six foot high blocks of concrete recessed in the floor and isolated from the rest of the building to reduce any machinery-induced vibration.

Over each stand, a hole has been cut in the ceiling to align the units

with the North Star as a reference. The stands are zeroed to within 10 seconds of arc, a seemingly impossible figure in view of their size.

In the laboratory, the gyros are mounted in heat units to simulate the operating temperature under which they must operate. The constant heat gives a constant viscosity to the high-density suspension fluid. Temperature is kept constant to within 0.004 or 0.005 degrees C.

While Arma realizes that such control is not possible in the missile, it feels that it is a definite aid in test and calibration to keep as many constants as possible to a precise figure so that more flexibility with unknowns can be gained. After mounting, the gyros are kept in the heat units all the time they are in the lab. The original heat units were spherical but Arma is now starting to use a new design that is cylindrical in shape and incorporates more advanced features to enable easier hookup for the various tests.

• **Quality control**—Another impressive feature in Arma's production setup is the quality control and environmental testing facility.

In the quality control program, a dual effort is carried on. In one phase, test-to-destruction methods are used to come up with primary selections of components.

In the other phase, large groups of components are placed in a long-range cycle to determine every possible fact about not only the units used in production, but as many competitive units as possible.

Rack after rack of semi-conductors, resistors, and capacitors go through life tests under a variety of conditions. In one test, components are assembled on a circuit board and run to failure at 85 degrees C.

The board presently undergoing this test has been operating for more than 14,500 hours, a good indication of the reliability of the system as a whole. In another test, typical circuit boards are taken to Brookhaven Atomic Laboratories and exposed to radiation in the atomic pile there.

While the transistors showed some deterioration after the irradiation, the circuit boards still operated and were well within design limits.

The environmental facilities are extensive and allow a complete environmental program to be carried on within the premises. Besides such standard facilities as hot and cold chambers, dust, sand, humidity, and salt spray simulators, installation is nearly finished on a huge walk-in Genisco rotary accelerator. The unit has a reported specimen capacity of 400 pounds and is isolated in a separate room with beefed-up floor and suspension.

• **Boss gets credit**—Much of the dynamic character of Arma's present operation can be attributed directly to Charles W. Perelle, president of American Bosch Arma for the past few years. Perelle, whose trouble-shooting in the past has run the gamut from Consolidated-Vultee to ACF-Brill Motors, has turned Arma from an engineering-oriented small company into one which operates efficiently and delivers on time, a quality not too common in the fast-growing missile business today.

Arma now builds hardware on a production line (unheard of at Arma in the past) and uncoordinated changes in a component after it reaches the production line is not tolerated.

Twelve Missile Men Killed in UAL Crash

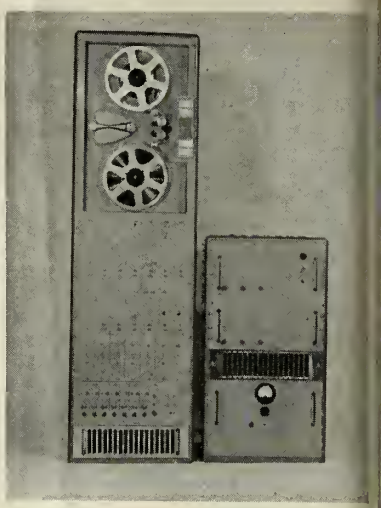
The missile industry was hit hard by the recent collision of a United Air Lines DC-7 with an Air Force F-100F near Las Vegas. Of the 47 persons killed on the airliner, 12 were directly or indirectly active in the missile field.

The Ramo-Wooldridge Corp. of Inglewood, Calif., which coordinates the Air Force ballistic missile program, lost two top employees: Robert Hight, 36, the company's treasurer and specialist in administration and finance; and William H. Torrans, 43, mathematics specialist on ballistic missiles in R-W's Space Technology Laboratory.

Several personnel from Gilfillan Brothers, electronics manufacturing firm, were enroute to Colorado Springs, headquarters of the Air Defense Command. The group included Wendell A. Simmons, vice president of the company; and two project engineers, John A. Petrie and Ralph Charles Kean, Jr.

Three Air Force Officers flying to Omaha, headquarters of the Strategic Air Command, were attached to Ramo-Wooldridge's missile program: Maj. Robert E. Darmody, Capt. Steve Paris and Maj. Lyndell T. Highly.

Four Norton Air Force Base civilian employees also were enroute to Omaha for a SAC meeting on missiles. They were Frank R. Pebles, Charles D. Matlock, Frank A. Theobold and Harold E. Thompson.



Tape Record-Reproducer Designed for Telemetry

Telectro Industries Corp., Long Island City, N.Y., has developed a tape record-reproducer unit for telemetry. Designed for maximum flexibility, it can be used for data acquisition, storage, reduction and phenomena recording.

Its modular construction provides easy access to amplifier components for inspection and service. It has a response range from DC to 120KC. Signal-to-noise ratio is better than 50DB from FM and 40 DB to AM.

There is a selection of six speeds from 1 7/8 inches per second to 120 ips. The unit can record two to 28 tracks simultaneously.

Carrier-based Missiles Pose Power Supply Task

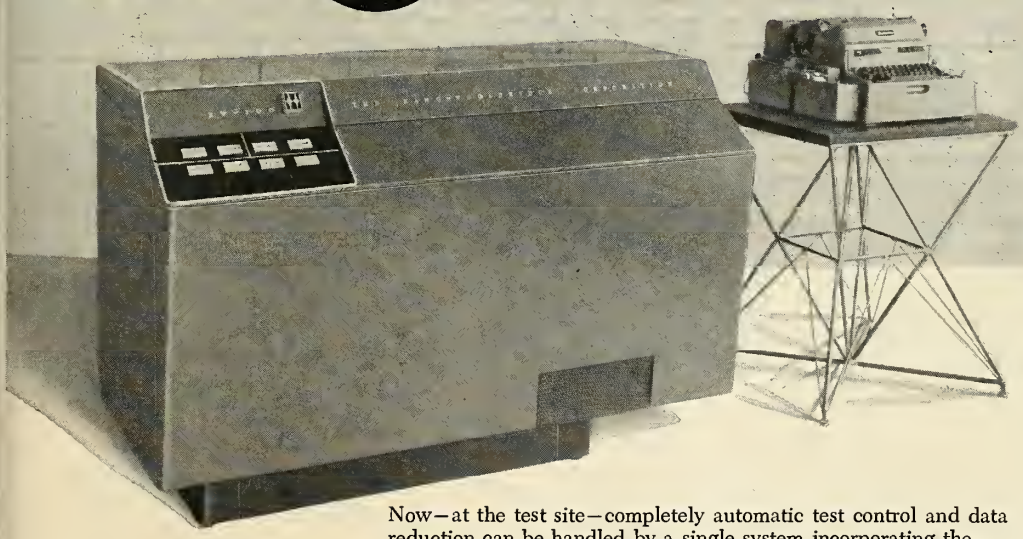
Providing electrical power for guided missile systems aboard new Navy aircraft carriers is presenting some problems, even though present-day carriers have power systems 10 times greater than those on the first carriers built in 1930.

The difficulty arises, according to Navy's Bureau of Ships, from the fact that missile systems require transient-free power closely regulated in voltage and frequency, and usually at voltages and frequencies other than that of the ship's basic generating plant.

The Navy has found that certain equipment in missile guidance requires 400-cycle power, with voltage and frequency tolerances not to exceed plus or minus ½% of steady-state values, with a recovery time not exceeding 0.1 seconds.

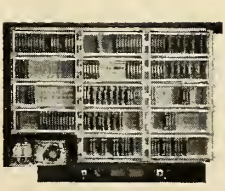
Such a requirement has made it

The RW-300 is the first digital computer for test control and data reduction



Now—at the test site—completely automatic test control and data reduction can be handled by a single system incorporating the Ramo-Wooldridge RW-300 Digital Control Computer. The new RW-300 can schedule and closely control test routines, and it can collect, analyze, and record test data.

The versatile RW-300 utilizes input data as feedback to modify control actions, thus substantially shortening many test routines. In addition, the RW-300 directly logs both instrument data and complex relationships among these data. Thus, test results are available immediately. The time-consuming task of processing raw data through a separate computer, often remote from the test facility, usually can be eliminated.



For technical information on automatic test control and data reduction with the RW-300 and with special digital systems which utilize solid-state components exclusively, write: Director of Marketing, The Thompson-Ramo-Wooldridge Products Company, P.O. Box 45607, Airport Station, Los Angeles 45, California, or call OSborne 5-4601.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

necessary to isolate each load and provide a special motor-generator set for supply. These sets have a magnetic clutch to regulate frequency and specially designed voltage regulators.

With these motor-generators and other special power supplies being fed by the carrier's basic distribution system, care has to be taken in laying out the system to isolate big motor loads that would create large voltage fluctuations. Such fluctuations could be reflected in the output of the power supplies.

With development of suitable line regulators and electric speed governors, the Navy hopes that a large number of small motor-generators can be replaced with large centrally located motor-generators.

Varian Establishes Unit for Radiation Equipment

Varian Associates of Palo Alto, Calif. have formed a Radiation Division with a staff of 24 engineers and 60 technicians and machinists.

Headed by Dr. William J. McBride, Jr., who less than a year ago was named to organize systems work, the new division will design and manufacture electronic equipment, components and particle accelerators.

During the past nine years, Varian's development of high-power klystron amplifiers has aided in the knowledge of previously impractical techniques for radar and communication systems. Varian's new division will make equipment for these systems. Under consideration are high power pulse and c-w microwave transmitters and transmitter components; microwave components and microwave test and measurement equipment.

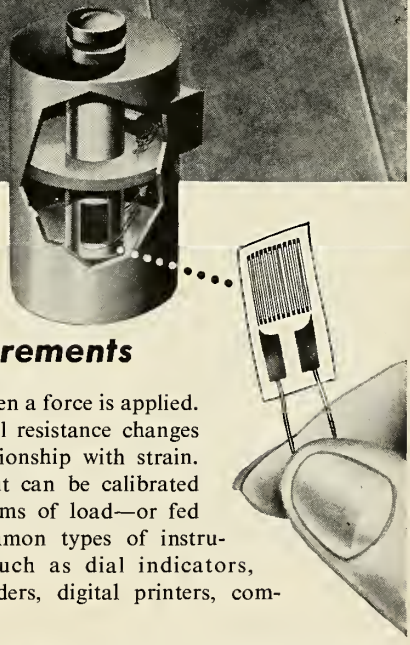
Compact Lycoming Unit Does Giant-Sized Job

A machine little taller than a man that duplicates and far surpasses the shock encountered by a giant missile reentering the atmosphere was recently announced by Lycoming Division, Avco Manufacturing Corporation. The unit can produce and accurately reproduce a shock of more than 100 times the force of gravity.

In operation, shock pulses are produced when the machine's carriage, dropped from a predetermined height, impacts against a molded lead pellet. Pulse shapes on an oscilloscope are controlled by the size and shape of these pellets.

Scientists tried various types of

In the wind tunnel of the Naval Supersonic Laboratory at M.I.T., a missile model is subjected to speeds of several Mach numbers. B-L-H SR-4 bonded wire strain gages report longitudinal and latitudinal stresses, drag, lift, etc., with high accuracy.



Here's why B-L-H electronic transducers are preferred for force measurements

There is an easy way to measure accurately any forces involving tension or compression, torque, etc. B-L-H SR-4® electronic transducers are compact, highly responsive, and extremely durable. Stock units offer lasting accuracy of ±1/10% and repeatability of ±1/20%. With appropriate instrumentation, they can determine center of gravity, weigh loads at rest or in motion, control batch and continuous processes, and record all data required. The type and number of applications are virtually unlimited.

The heart of every B-L-H transducer is its SR-4 bonded wire strain gages. They are bonded to a metal element in the transducer and approximately 10 milliamperes is fed through them. They receive the same strains as the transducer when a force is applied. Their electrical resistance changes in linear relationship with strain. Voltage output can be calibrated directly in terms of load—or fed into any common types of instrumentation, such as dial indicators, graphic recorders, digital printers, computers, etc.

For more information on B-L-H electronic transducers—load cells, pressure cells or torque meters—ask to have a B-L-H man call on you or write to Dept. 9-E for a copy of Bulletin 4300.

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metal compounds for the pellets, and finally settled on plain plumber's lead. With this material, the machine can produce a wide variety of shock pulse shapes.

The unit accommodates specimen loads up to 40 pounds.

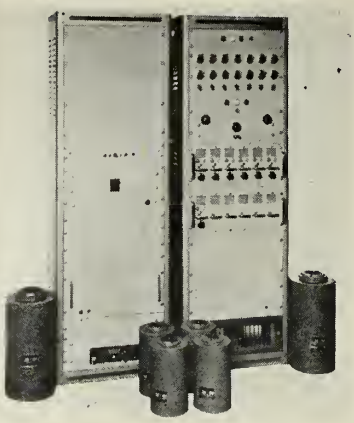
GE Has Monopropellant Power Unit Ready

General Electric's Aircraft Accessory Turbine Department has developed a monopropellant hydrazine auxiliary power unit for missiles delivering 40 horsepower for a total weight of 99 pounds, including alternator, hydraulic pump and fuel supply. GE AATD provides a number of missiles with APU equipment. It also has the contract to supply North American Aviation with the accessory power supply for the rocket-powered X-15.

New System Measures *Atlas* Weight and Thrust

A six-component thrust measuring system—to indicate and record values of missile weight, propellant weight, thrust, gimballing, motor force, and thrust mis-alignment force—has recently been displayed by the Gilmore Industries of Cleveland, Ohio.

On the *Atlas* installation, four of the load cells are mounted underneath the



missile to measure weight and thrust; the other two cells are mounted along the length of the missile to measure side-loading. When the missile is fired, the unit reports the complete thrust buildup, and if the engines are not operating properly, the launching can be stopped.

Forces measured by the system are translated into values represented by terms (a) weight and thrust, (b) pitch moment, (c) yaw moment, (d) roll moment, (e) XX axis sideload, (f) YY axis sideload.

The system compensates for the effect of sideload with respect to wind and interaction with moments. Computing equipment isolates all fixed components. A portable calibration unit, calibrated by the National Bureau of Standards, is included in the installation.

At the present time, four systems are installed at Cape Canaveral and three at Edwards AFB, California.

m/r Continues Expansion of Editorial Staff

In preparation for maintaining complete weekly coverage of the missile and rocket industry, m/r has added four editorial staff members to its Washington office. The magazine, which will become a weekly publication in July, has recently added a managing editor, several associate editors and other members, bringing the total present editorial staff to sixteen. Additional appointments will be made prior to the conversion to weekly frequency.

C. A. Hurt, assistant publisher, was formerly assistant publisher of Tooling and Production Magazine and has over eighteen years experience in the industrial sales and sales management fields.

Donald E. Perry, assistant editor, was previously with The Martin Co.'s public relations department at Orlando, Fla. His duties with Martin included preparation of technical brochures and other publications. He is a former aviation editor of several Southern and Midwest newspapers.

Ellen Rosenbloom, copy editor, was formerly with United Press and the Bureau of National Affairs. She holds

SMALLER, LIGHTER PAM-FM SYSTEM
USES LESS POWER; TRANSMITS BETTER

A report to Engineers and Scientists from Lockheed Missile Systems — where expanding missile programs insure more promising careers

Lockheed Missile Systems engineers and scientists have developed a PAM-FM telemetering system that weighs less, is smaller, uses less power, yet operates much more efficiently than conventional systems. The new transistorized time-division multiplex system is being tested for use in monitoring future flights in connection with the Division's major missile system projects.

Lockheed holds two top U.S. defense super-priority programs: The Navy Polaris IRBM, and the Air Force reconnaissance satellite. In addition, the Q-5 target ramjet and X-7 test missile programs have been expanded. Qualified engineers and scientists who join our Division at this stage in its development are thus assured better opportunities to move ahead rapidly.

Besides **Telecommunications,** positions are open in **Radar and Data Link, Antenna, Solid State Electronics, Guidance, Flight Controls, Information Processing, Ground Support Equipment, Systems Integration, Human Engineering, Reliability Engineering, Test Planning** and **Analysis** and **Aero-Thermodynamics.** If you are qualified, your inquiry is invited. Please write Research and Development Staff, Palo Alto 7, California.

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Dr. J. W. Muehlner, Telecommunications Department Manager, left, discusses proposed packaging of the PAM-FM system with Daniel Hochman, Development Section Head.

a B.S. degree in Journalism from Syracuse University.

Thomas D. Near, editorial assistant, has just finished a three-year tour of duty with the Navy, where he served as communications and personnel officer. He holds a B.A. degree in journalism from the University of Minnesota.

New Group Set Up On Control Instrumentation

Electronic Associates, Inc. of Long Branch, N.J., has entered the automatic data processing and process control fields by forming a control instrumentation section within the company's engineering department.

Dr. Wolfgang Harries, German physicist, who has contributed to the design and development of aircraft and missile control systems, advanced radar systems, and precise generation and synthesis, is heading the group.

The group will be concerned with data logging, closed loop control systems, computer entry, and computer linkage systems. For more than a year, the company has been conducting an intensive development program on low lever amplifiers, transducer calibration units, electronic multipliers, voltage-digital converters, universal digital logic elements, and controlled format digital tape recorders.

Navy Breaks Record For Conventional Aircraft

Terming the flight an "invasion of the edge of outer space," the Navy on April 17th announced that LCDR. George C. Watkins, flying an F11-1F Super Tiger jet fighter, broke the world's altitude record for conventional aircraft.

Taking off from Edward's Air Force Base, Watkins took the jet up to 76,828 feet. Watkins said he was hoping to double the record set by Lt. Apollo Soucek, USN, in 1929. This would indicate the Navy is shooting for better than 80,000 feet with more or less conventional craft.

The Navy said additional altitude attempts would be made; and with improved weather and temperature conditions, the April 17 record might be topped.

Watkins' altitude topped the previous record of 65,000 feet set by a British Canberra in altitude tests conduted last year.

Instrument Society Sets Sept. 15-19 Convention

The 13th annual Instrument-Automation Conference and Exhibit, sponsored by the Instrument Society of America, will be held September 15-19 in Philadelphia Convention Hall.

The technical portion of the five-day program will include workshops in instrument maintenance, sales engineering, data handling, control systems and computers.

The conference will show how certain industries—aviation, chemical, petroleum, metals, nuclear, ceramics, and transportation—have made new discoveries, processes and techniques through the use of instrumentation and related techniques.

The data handling workshop will have sessions on wind tunnels, flight propulsion, process industries, power generation, oscillagraphic and photo-panel data, data transmission and storage, analog-digital converters, real-time digital computer applications and transducers.

Personnel from Moore Products Company, American Viscose Corporation, Minneapolis-Honeywell Regulator Company, Leeds and Northrup Company and Fairless Steel Works will hold the instrument maintenance clinic—always a major feature of the meeting—on September 14-15.

FASTER WORK on missile logistic support is objective of Maj. Gen. E. W. Anderson (center), commander of San Bernardino Air Materiel Area.

Computer Setup Aids Logistic Support

Semi-automatic logistic support of ballistic missile squadrons will become a reality when an electronic data processing system goes into action at Norton AFB, San Bernardino, Calif.

Expected to be in daily use by July, the installation will be one of the largest IBM 705 data systems in the world.

Designed specifically for support of *Atlas* and *Titan* ICBMs and the *Thor* IRBM, this processing center will expedite supply actions by connecting the operating squadrons, supporting AMC bases and ballistic missile contractors in a communications network.

• **Working process**—During normal checkout of a vehicle at a launching site, some component of a missile may be found deficient. The component is then removed and returned to the supply unit of the parent squadron. In normal procedure, the squadron issues a replacement part to the site.

When the squadron's stock level of a part has been reduced by one, it will be reported to the Norton management center by an issue transaction card communicated electronically through an IBM transceiver.

Information from the squadron is applied to the computer input, and the corresponding inventory record for the part is located through master inventory records on IBM 727 magnetic tape units.

When the transaction is posted to the master record, the computer also notes the squadron's balance.

This triggers a computer-created shipping order on one of the 30-odd 727 magnetic tape machines, which then directs an AF-operated contractor storage site to ship the required quantity of the replacement part to the field squadron. This order is transmitted directly to the appropriate storage site by an IBM transceiver.

• **Final action**—Upon receipt of the shipping order, the storage site sends the parts requested and notes this action with a transceiver-sent shipping notice transaction card.

When this information is applied to the computer, it locates the master inventory record of the appropriate part and adjusts the balance remaining at the storage site.

A record of shipment is also made in an in-transit file, where the quantity is recorded on magnetic tape. An additional in-transit notice is created on magnetic tape and sent via the transceiver to inform the squadron that action has been taken.

When replacement parts are received at the squadron, it is acknowledged over the transceiver. This data is received at the management center and fed into the computer—wiping out the in-transit balance and increasing the squadron's serviceable balance on master inventory files.

The system requires about 200 full-time personnel for efficient operation. Under a lease arrangement, the 705 and associated equipment costs the AF about $60,000 per month.

Shock Machine to Test Ballistic Missile Parts

Lycoming Division of Avco Manufacturing Corp. will manufacture a shock machine for testing ballistic missile components, to be used particularly on the *Titan*.

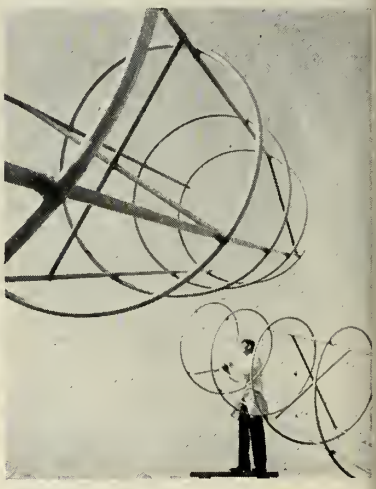
The machine was developed by the Research and Advanced Development Division of Avco, prime contractor for the nose-cone development of *Titan*. It can produce, and accurately reproduce, sawtooth-wave shock patterns of more than 100 g's over a shock response spectrum of 80 to 1000 cycles per second.

The machine provides a specified terminal-peak sawtooth pulse shape rising to 100 g's in 6 milliseconds and then dropping to zero. It also provides wave patterns including quarter- and half-sine wave shocks.

From a pre-determined drop height, the carriage hits a molded lead pellet. By controlling the size and shape of pellets, many pulse forms can be obtained.

The specimen carriage is pneumatically positioned and released for fall by a solenoid-operated mechanism. Pellets are placed on an anvil set in the 2,000 pound concrete base.

The machine accommodates specimen weights up to 40 pounds and a cross-sectional area up to 12½ inches square. It can test many items of electronic and mechanical equipment used in advanced ballistic missiles, and other equipment subject to high impact loads.



Radar Monitors *Atlas* Ionosphere Tests

Doppler radar will be used to conduct ionospheric investigation during tests of the *Atlas* ICBM. The probing will be done by Space Technology Laboratories, a division of the Ramo-Wooldridge Corp.

Three portable trailer units containing Doppler radar will be spotted at the Cape Canaveral Air Force missile test center. Scientists will investigate the difference in frequencies recorded by the radar as the *Atlas* goes through the ionosphere.

With knowledge of the missile's speed and altitude, electron density measurements can be obtained ten times more precise than previously possible.

No special test instrumentation will be added to *Atlas* ICBMs for this research. Presence of free electrons affects guidance and radio communication. The use of low frequency waves beamed into the ionosphere and bounced back to earth are not accurate enough for missile and space vehicle studies.

New Transistor for Very High Frequency Use

Texas Instruments Inc. of Dallas has developed a new high frequency diffused base germanium transistor for commercial use. It will give high gain

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The transistor's switching time of 25 millimicroseconds in a non-saturated circuit configuration makes it applicable for high speed computer applications. It has a –30 volt breakdown voltage and 40 milliwatts total dissipation at 25°C.

New Ground-To-Ground German Rocket Developed

H. G. Mebus, former Enzian rocket engineer, has developed a new ground-to-ground rocket designed for anti-tank use. Using a hypergolic bipropellant system, the pressure-fed rocket motor has the following characteristics:

Empty Weight, lb.	13.2
Propellant Weight, lb.	8.8
Total Weight, lb.	22
Diameter, in.	4.9
Length, in.	37.4
Booth Thrust, lb. x sec.	110x3
Sustainer Thrust, lb. x sec.	44-66x20-30

With such a motor, a typical AT rocket would be:

Powerplant Weight, lb.	22
Tanks, Frame, Fuselage, lb.	6.6
Guidance, lb.	6.6
Warhead, lb.	4.4
Total Weight, lb.	39.6
Velocity (after 3 sec.), ft./sec.	262
Burnout Distance, ft.	3950-4400
Free Flight Distance, ft.	3280
Total Range, ft.	7200

Both cooled and uncooled motors are being tested. The rocket will be produced by Mebus Holz and Metallbau, OHG.

ARDC Project Space Track Conducted From Cambridge

Air Research and Development Command is conducting its project Space Track from the Air Force Cambridge Research Center at Bedford, Mass. The project, established last November, is intended to provide complete tracking of all artificial earth satellites.

Under Space Track, observational data is exchanged with the Smithsonian Astrophysical Observatory, which has primary responsibility for the optical tracking program of the IGY satellite program.

High-power beamed radars will be used to increase the number of times when orbital fixes can be obtained. Radars will be located at Millstone Hill, Laredo, and the Stanford Research Institute. Several AF contractors are reported to be developing passive infrared detectors to increase the number of satellite observations.

Bomarc Ground Support Equipment To Be Built

Food Machinery and Chemical Corporation today announced the receipt of a production contract from Boeing Airplane Company, Seattle, to build launcher-erectors and power-pack units for the Boeing *Bomarc* interceptor missile.

The number of units involved was 56; the dollar amount of the contract was $1.4-million or $25-thousand per unit.

The *Bomarc* ground support equipment will be built at FMC's Ordnance Division facilities in San Jose. This division is also producing the transporter-erector and launching base for the Air Force's IRBM *Thor* under a contract awarded in February by Douglas Aircraft Company, Inc., Santa Monica.

FMC's Ordnance Division is also producing the *Hawk* loader vehicle for Northrop Aircraft, as part of the Army's *Hawk* weapon system.

Committee on Electronic Weapons Reorganized

The Engineering Department of Electronic Industries Association recently announced reorganization of its Reliability Committee to provide a more dynamic coverage of the field of electronic weaponry and allied fields.

Renamed the Military Electronic Applications Committee; the new committee will have as chairman L. M. Clement, of Avco Manufacturing Co.

In addition to the Committee redesignation, subcommittees have been established and their new chairmen announced as follows:

Reliability—L. M. Clement.

Maintainability—Maj. Gen. F. L. Ankenbrandt of RCA.

Value Engineering—Rear Admiral R. S. Mandelkorn (USN-ret.) of Lansdale Tube.

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MST 821... *the highest strength weldable sheet & bar alloy in 400—1000°F range*

MST 2.5Al-16V... *the first readily formable, heat treatable sheet alloy*

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MST 2.5Al-16V was developed in response to needs of the airframe industry for a sheet alloy which would be soft and formable in the annealed condition, and which could be heat treated, after forming, to high strengths while retaining ductility. With this material, yield strength can be as low as 50,000 psi, to permit easy fabrication, then increased to 150,000 psi by heat treatment. Age hardened sheet has good short-time hot strength—about 100,000 psi yield strength up to 800°F.

These alloys, now in limited commercial production, are further evidence of rapid advances in titanium. Use Mallory-Sharon's outstanding technical experience and service on your present requirements — or future plans—in titanium.

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Air Force Investigating New Detection System

The Air Force is trying to determine the feasibility of using electromagnetic radiation as the basis for a passive ICBM detection system that would pinpoint a long-range missile firing within two minutes of takeoff. The method would obviate the necessity of waiting until a missile reaches extreme altitudes before detection by powerful radars.

The new system, far from perfection but technically feasible, is still hamstrung by the "line-of-sight" restriction that limits the effectiveness of radar, but it shows great potential for a breakthrough in this area.

Being passive, the system eliminates the requirement for huge amounts of power needed for installations such as the 21-million-watt radar recently developed by Cornell Aeronautical Laboratory, Inc.

The Air Force has already contracted for the study of steerable beam linear arrays for a missile-borne target-seeker antenna system. This is part of a three-phase contract awarded to TRG, Inc., New York.

The other two phases of the TRG contract also involve electromagnetic radiation research, including study of the Zenneck wave, a phenomena reported to be the solution to propagation around the earth.

Excitation of the Zenneck wave results in detectable radiation, but the rate of attenuation is undisclosed. The wave can exist at almost any frequency, but most likely has practical applications at low frequencies. Excitation of the Zenneck wave is possible in several ways, but rocket exhaust characteristics are most applicable to the Air Force detection concept.

On takeoff of an ICBM, tons of chemicals emerge from the rocket exhaust in the form of ionized gases, which radiate on frequencies dependent upon the nature of the molecules and their temperature.

This is basically known as "white noise" and is detectable, but so far only in "limited ranges." There has been no elaboration on what the Air Force calls a "limited range."

The Navy recently disclosed that it has information on an "amazing" new breakthrough in global detection that was made possible by the two Soviet Sputniks.

The processes of ion emission referred to by Rear Adm. John T. Hayward are possibly connected with the similar Air Force project. In testimony

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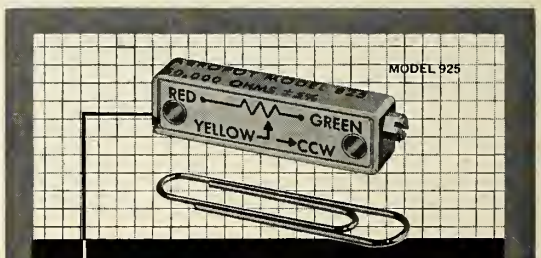

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before the House Outer Space Committee, Admiral Hayward said that objects traveling through space leave "ion trails" which are detectable.

SAC Center To Plot ICBM Trajectories

The Air Force's Strategic Air Command is building an underground missile control center at its headquarters, Offutt AFB, Nebraska, for the plotting of ICBM trajectories. The center will be an underground addition to the present SAC control center, and is expected to cost about $800,000.

The centralized operation will be manned by the Air Force's first missiles target squadron, now in training. The concentration of men and computers at the Offutt headquarters is expected to result in more economical operation and better utilization of the specialists.

A SAC spokesman indicated that work also will begin on a three-story superstructure over the target trajectory center to house an air-combat intelligence operation. An additional 60,000 square feet will be available to the SAC control center as a result of this new construction.

The new underground facility will not be designed as a heavily fortified and protected operation. However, the weight of the equipment calls for interior floor loads of 250 lbs. per square foot, as compared with a 65-lb. load for the rest of the center. This necessitates substantial construction, which will in itself afford a high degree of protection.

Telemetering Conference In Baltimore, June 2-4.

A national conference on telemetering is scheduled to be held in Baltimore on June 2-4. The conference, which will highlight discoveries made by man-made earth satellites during the International Geophysical Year, is sponsored by the American Institute of Electrical Engineers, the American Rocket Society, the Instrument Society of America, and the Institute of Aeronautical Sciences.

The IGY program will deal not only with radio and wired telemetering, but with the newer medium of transmission, sonic telemetering. Telemetering in the general fields of oceanography, astronomy, cosmic ray and rocket sounding studies also are on the agenda.

Featuring the IGY, papers will be presented by telemetry experts from the U.S., Switzerland, England, France, Italy, and possibly Russia.

m/e briefs

RCA is believed to be supplying the electronic payload for the Army Ballistic Missile Agency's projected reconnaissance satellite. This project reportedly has priority over any other space flight program at the Agency. Army claims the advantage of its system is a 50-mile overlap, while the Air Force proposal includes a 100-mile gap in viewing.

USAF Gen. Irvine says that there is now a "vigorous program" underway to extend the life of the AF WS-117L, (sometimes called *Pied Piper*), by developing secondary power sources including nuclear power and solar energy.

Reported limiting factor now on accelerating missile tests is instrumentation needed to permit simultaneous countdowns on more than one missile.

Army Signal Corps has awarded RCA a $5-million contract to follow up on a purported major breakthrough in miniaturization. The term is for two years, and RCA is to develop a "micromodule" concept to the point where existing electronics systems can be produced in one-eighth their present weight.

DOD has formed a standardization committee to work with guided missiles. The group will develop and recommend missile standardization plans for the assistant defense secretary for supply and logistics. Details appear in DOD directive 5126.20.

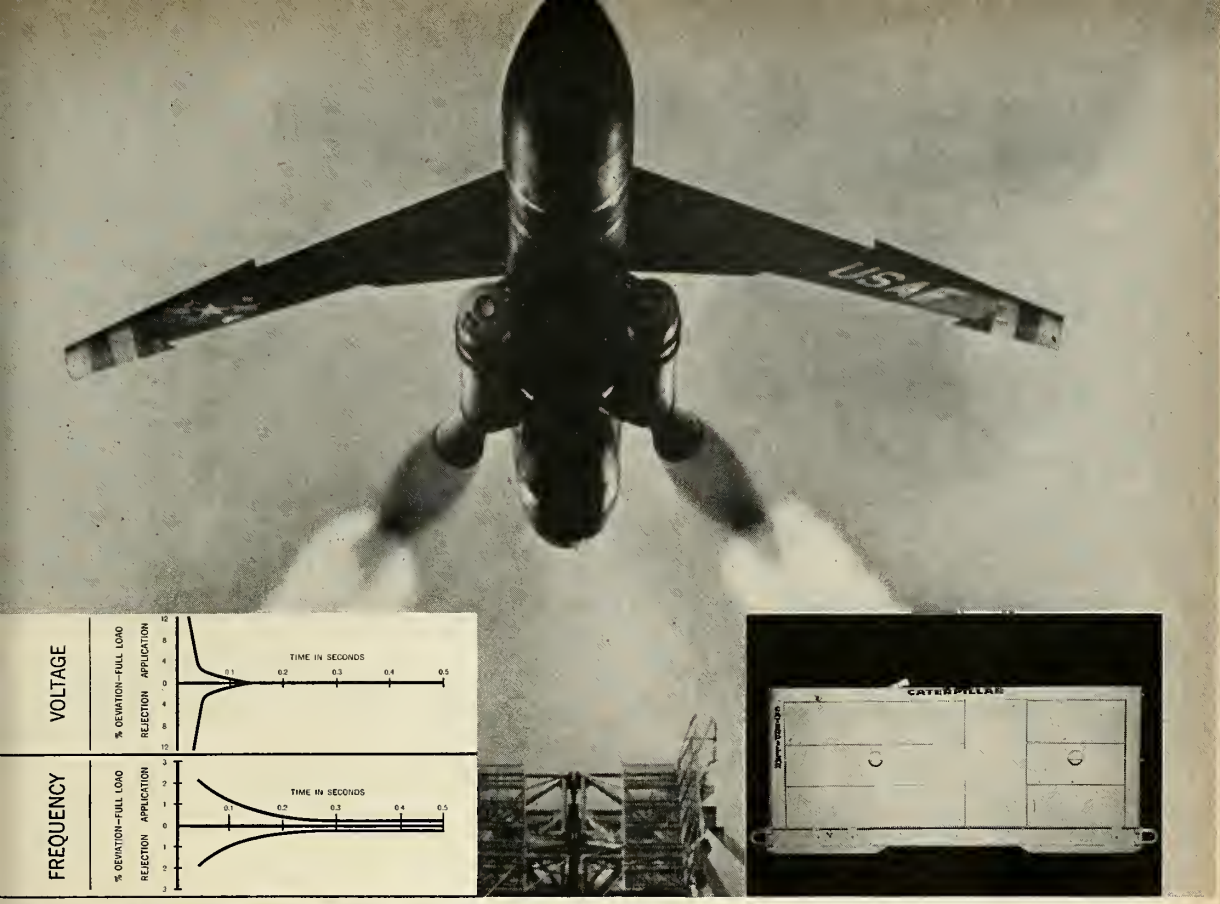
The Small Business Administration has a list of 500 military prime contractors who received $10,000 or more in government business in FY1957. Companies seeking subcontracts in experimental, developmental, and research fields may have the list upon request.

One reason for the firing delay of *Explorer* IV is the incorporation of a new experiment based on information received from *Explorer* III. One speculation is that this information would concern the science of testing electromagnetic waves

B/Gen. Beverly H. Warren says about 50% of AF's procurement dollars are going for electronics.

21st Century Electronics has a new 12,000 square-ft. lab facility in Palm Springs, Calif. for R&D into missile systems and IR proximity warning devices.

AVCO Research Laboratory has



The almost instantaneous return to normal of the new low-silhouette Cat power unit under conditions of full-load application, and load rejection (117.4 volts), is shown in the above graph.

Low-silhouette Cat power unit with close voltage regulation is now being used in connection with ground support for jet starting and firing. The 400-cycle phase is specifically adopted to missilry.

Caterpillar power fires SNARK... first U. S. intercontinental missile

The U. S. Air Force SNARK SM-62, the first U. S. intercontinental guided missile, is fired with power from an electric set, developed by Caterpillar and now being supplied to the military.

The full designation of this specialized power unit is Caterpillar 60 KW 400-cycle 120-208 voltage low-silhouette portable ground support unit with precision voltage regulation.

The secret of this unit is the almost instantaneous recovery to both applied and rejected loads.

Other advantages found in all Caterpillar Engines include: trouble-free operation over a wide range of loads; dependability and long life; economy of operation; maintenance and operation by unskilled personnel; world-wide parts and service, and the ability to operate on any fuel from JP-4 through No. 2 furnace oil.

Creative engineering and quality of manufacture have made Caterpillar the diesel leader for more than 25 years. For detailed information on the Cat 60 KW 400-cycle portable power unit with close voltage regulation, send in the coupon below.

Engine Division, Caterpillar Tractor Co., Peoria, Ill., U. S. A.

ENGINE POWER BY CATERPILLAR

Dept. M15, Engine Division
Special Governmental Projects
CATERPILLAR TRACTOR CO., Peoria, Illinois, U. S. A.

Please send me additional detailed information on Ground Support Electric Sets.

Name_____

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pushed hydrogen and deuterium to velocities of 500,000 mph using experimental pulsed electro-magnetic accelerators.

Thinking of the kind prior to a breakthrough is evident in the gyro field lately. One device, the electron gyro (not yet built), would accelerate electrons to relatavistic speeds within a closed circular field. Another, the electrostatic gyro, would work by spinning a freely suspended solid sphere concentrically within another sphere, and measuring the electrostatic field displacement as the spinning sphere is moved toward the wall of the external sphere.

Lt. General Arthur G. Trudeau, Army Chief of Research and Development, will head the military delegation at a series of closed discussions on "Electronics on the Battlefield." Meetings are being held for key military and scientific leaders at Fort Huachua from April 29 to May 1. The event is the sixth in a series arranged by Army's R&D chief, dealing with overall R&D problems in the Army.

ON PYLON of the Fouga 170 Magister is Nord Aviation's *SS-11* missile. The plane carries two missiles, which can be equipped with either armor piercing or shrapnel warheads, for use in ground-to-ground, air-to-ground, and air-to-air combat. Minimum firing distance is 1,968 ft.; maximum 11,428 ft.; except when used as a target missile where the most favorable distance is 4,920 ft. Tests show that for ground firing, aircraft altitude can be between 3,280 and 4,920 ft. for firing along the center line. Lower than this, a difference of 10-20 degrees is encountered between the trajectory of the aircraft and that of the missile. Beyond 45 degrees, firing is not precise.

ENGINEERS, E E

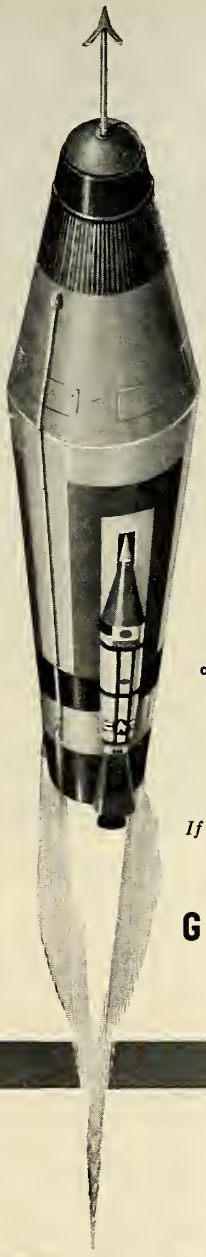
A program that is attracting some of the best minds in electronics now calls for additional creative engineers

GUIDANCE SYSTEM FOR AIR FORCE ICBM ATLAS

UNDER DEVELOPMENT AT GENERAL ELECTRIC

There is an unprecedented challenge for electronic engineers in developing the command radio-radar system for Atlas.

Portions of this system must achieve *accuracies on order of 1 part in 10 million* ...and maintain them without degradation under the extreme conditions of shock, vibration and temperature encountered during an ICBM's blast off and acceleration along the initial portion of its trajectory.



Men who can work to these stringent operational requirements will be well equipped to handle still more demanding "command" problems. As the Manager of General Electric's Missile Guidance Section said recently: "With this job behind us, there will remain no significant obstacle to the practical guidance and navigation of other space vehicles."

Current opportunities at the Section are at all levels... and exist in practically every phase of the program.

If your field of special competence appears in the list below there may be a position open to you, with high professional implications for the future.

Systems analysis, evaluation & integration • Systems and component reliability • Transistorized circuits, pulse circuitry, IF-Video circuits • RF and Microwave components & plumbing • Communications control devices • Doppler radar design & development • Digital data processing techniques, data transmission involving D & D of ground-based & airborne antennae, transmitters, receivers; application of transducers, transponders, etc. • Test operations, including planning, range instrumentation & test execution; development & application of automatic test equipment.

Positions are at Syracuse and Utica, N. Y. facilities.

Please address your resume to Mr. E. A. Smith, Dept. 5-G

If your qualifications approximate job "specs," he will arrange a convenient interview.

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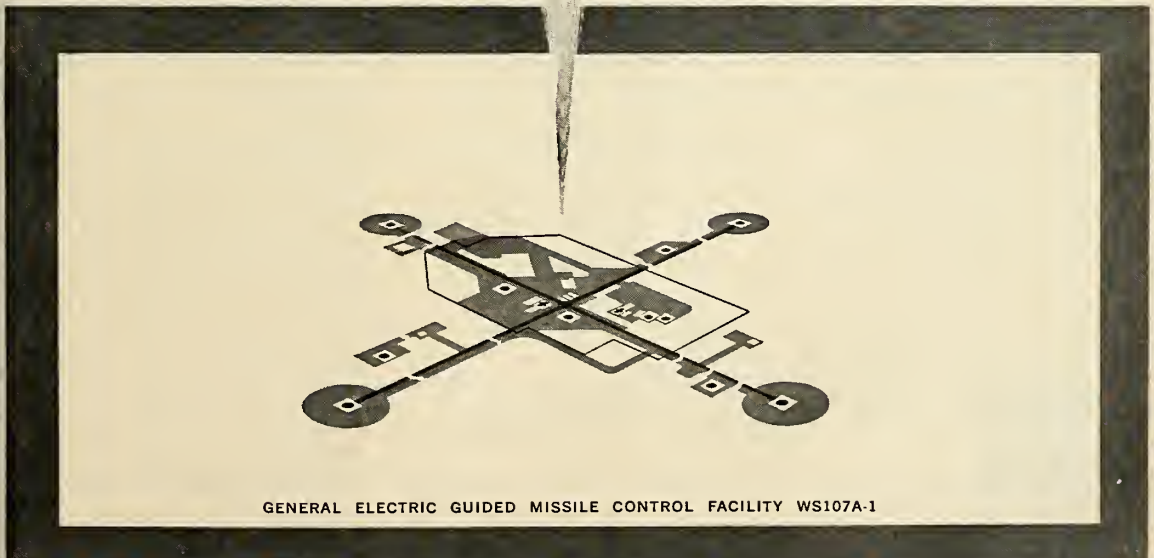

GENERAL ELECTRIC GUIDED MISSILE CONTROL FACILITY WS107A-1

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There's a whole new way of life for you between the covers of "Opportunities Abound at Bendix Missiles" —and a three-cent stamp will bring it to you by return mail. If you have the qualifications, Bendix can offer you an enviable career in the guided missiles field, working with men who have been responsible for some of the most significant missile engineering advances of recent years.

At Bendix, you will be in a major missile program. Bendix as prime contractor has responsibility for the Talos guided missile, one of our most vital defense weapons. Using the finest equipment, you'll learn fast and grow fast, both professionally and financially. There's opportunity here—opportunity to do important, stimulating work.

You'll like living in the Middle West. The climate is pleasant and Chicago, Lake Michigan and other fine recreational areas are easily accessible. There is also opportunity locally to pursue graduate engineering studies. Mail the coupon below. The book may not be a best seller, but it has been the instrument which started many a talented engineer on a fine career in engineering.

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NEW PRODUCT BRIEFS

TOMATIC TURRET. New two-posi- automatic turret, with hydraulic uation, designed to accommodate 1"x1½" tools features turret index 180° to a positive stop in either ction. Operation is entirely auto- ic; control being supplied during chining by the multicycle program- mechanism of the Mona-Matic e for which the unit is specifically ineered. Accuracy is claimed to be xcelled for an automatic turret unit his type. Monarch Machine Tool Co.

le No. 270 on Subscriber Service Card.

VO COMPONENT. Packaged unit sisting of an integral combination of two-phase instrument servomotor, r reduction, slip clutch and preci- potentiometer. Unit offers preci- servo performance in a modular struction. The Diehl Servopot is med to eliminate present burden of unting, testing and aligning separate s. Has wide application in balanc- positioning and computing servo- chanisms. Addition of an integrally unted Diehl a.c. tachometer with a % linearity makes the Servopot a plete integrating servo. Diehl Mfg.

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ATED RATE GYRO. Subminiature ed rate gyro with high resistance hock and vibration, and having uni- damping over the entire operating e withstands 100 g's of shock and g's at 2000 cps vibration in any for even the lowest available rates. zes jewelled bearings and a pivot supporting medium for the gimbal. torsion bar used as a restraining ce is not required to absorb shock vibration. Fairchild Controls Corp. ponents Division.

e No. 272 on Subscriber Service Card.

BORER MICROSCOPE. This in- ment has been specially designed locating microscope in jig borers similar precision machine tools. cally it combines at 25x total mag- fation a fairly large field with suffi- power of observation. The eye- e contains a hairline cross and is table for individual focusing. Stand- shanks are ½" straight, No. 2 and 3 Morse Taper. A flexible spot inator is available for independence shop lighting conditions. Micro- e is of Leitz-Wetzlar (West Ger- make and is being introduced by o-Metric Tools, Inc.

No. 278 on Subscriber Service Card.

DROP TEST MACHINE. Model 30K, which provides shock forces in excess of 77 g's on specimens weighing up to 400 pounds, said to eliminate uncertainty of impact repeatability inherent in the conventional types and bed machines. Consists of a piston type platform on which the equipment to be tested is mounted. Platform is then subjected to a free fall into a cylinder of air pressure. Provisions are made to mount an accelerometer to the platform which supplies acceleration data to a recording device. The advantages offered by the Model 30K is "Repeatability" of acceleration waveforms and simplicity of operation to obtain shock calibrations. Aeroflex Corp.

Circle No. 279 on Subscriber Service Card.

HIGH TEMPERATURE BOBBINS. Recently developed high temperature bobbin that meets and exceeds military specifications for Class "H" insulation. The bobbin has been tested and approved to withstand temperatures up to +250°C. Specifications include material thickness from 1/32" to 1⅛" round, square, or rectangular shapes. Available for ⅜" to 1½" inside diameter coil sizes and any diameter of flange.

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POTENTIOMETER. A liquid-filled potentiometer with all moving parts sealed in a bath of oil said to be one solution for degradation and performance problems experienced with precision potentiometers. Significant advantages claimed over conventional models include as many as 20-million shaft revolutions, greatly reduce noise, increased dielectric strength, prolonged shelf-life, greater heat dissipation and operation under water. Helipot Corp.

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TITANIUM FORMING LUBRICANT. A titanium forming lubricant, known as T-50, has been developed by EverLube Corp. T-50 is said to solve titanium forming problems by reducing galling and permits lower die temperatures. The material can be sprayed or brushed, and air dried. After forming, T-50 is easily removed with solvent.

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PORTABLE POWER SOURCE. Used to furnish preflight power for guided missiles and missile checkout trailers. The 400-cycle motor generator is synchronous motor driven and operates at 1200 RPM. Kato Engineering Co.

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Product Mfg./Service Offered _____

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MISSILE LITERATURE

DISCONNECT COUPLINGS. Catalog describing special quick connect/quick disconnect couplings for guided missile and aircraft use, and other applications. Most of the special couplings shown feature remote disconnection which can be by either solenoid or lanyard action, but emergency manual disconnect can also be provided. Designed with large, smooth ID passages to handle gases, hydraulic fuels, oxidizers, jet and turbine aircraft fuels and synthetic oils, valves on both couplers and nipples shut off with no leakage when disconnected. Snap-Tite, Inc.

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METHANOL. Brochure on methanol, describing its varied applications, physical properties, and specifications. The brochure also provides information on handling, storage, health hazards and precautions and includes a chart showing the properties of water-methanol solutions. Reichhold Chemicals, Inc.

Circle No. 204 on Subscriber Service Card.

TRANSDUCERS AND CARRIER SYSTEMS. Carrier systems, including the remarkable new 9-oz. Instrument Translator; systems for indicating and recording torque, pressure; and transducers for high-precision measurement of linear displacement, rotation, force, flow, velocity and liquid level are described in new short form catalog. Crescent Engineering & Research Co.

Circle No. 205 on Subscriber Serivce Card.

INVESTMENT CASTINGS. Eight-page brochure featuring information on designing for investment castings. Design information covers such factors as fillets, holes, threads, wall thicknesses and tolerances.

One section is devoted to a discussion of ferrous and non-ferrous alloys which can be used for investment castings.

The literature is illustrated with photographs of nearly 100 investment cast parts.

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MAIL-ORDER ELECTRONICS. A new catalog listing more than 200 components most frequently used in control equipment has been released. The catalog enables engineers to use a "Sears Roebuck" approach to purchasing electronic and electromechinical components. Servomechanisms, Inc.

Circle No. 210 on Subscriber Service Card.

TITANIUM LAB REPORTS. Three reports of research by the Battelle Memorial Institute's Titanium Metallurgical Laboratory under the titanium development program of the Department of Defense have just been released to industry through the Office of Technical Services, U.S. Department of Commerce. Another Battelle report which reviews the industrial status of high-strength aircraft steels also is available. Dept. of Commerce.

Circle No. 214 on Subscriber Service Card.

ALUMINUM ALLOYS. Three reports of Armed Forces research on aluminum alloys, one of which compares the efficiencies of vacuum and nitrogen degassing techniques to eliminate porosity, have just been released for industry use through the Office of Technical Services, U.S. Department of Commerce.

Circle No. 213 on Subscriber Service Card.

STRAIN GAGE MEASUREMENTS. Four page technical brochure "The Resistance Bridge Indicator and Its Applications" suggests many applications of this instrument which can be calibrated to indicate directly in microinches of strain, psi, pounds, ft. pounds, etc., depending upon the type of strain gage type transducer being used. Included is a simplified schematic diagram to show how the "shunting effect" across the transducer bridge is always the same regardless of the position of the follow-up potentiometer in the dual-potentiometer circuit. Another schematic illustrates how millivolt signals may be measured. The text discusses how this instrument, when supplied with an analog to digital shaft convertor, becomes the heart of a multichannel automatic digital recording system. Datran Electronics.

Circle No. 200 on Subscriber Service Card.

CATALOGS OF TECHNICAL REPORTS. Four CTR's have been published by OTS. The CTR's list all research reports available from the OTS collection in the fields of rectifiers, propellants, photogrammetry, and paper and allied products. Many of the reports listed in the catalogs are the result of research conducted for the Army, Navy, Air Force and other agencies of the U.S. Government. Others are German documents captured by the Allies during World War II. All reports listed are for sale to the public, some in printed form from OTS and others in microfilm or photocopy from the Library of Congress. Department of Commerce.

Circle No. 201 on Subscriber Service Card.

PARTS REFERENCE BOOK. A new 2[illegible] page illustrated engineering reference book on molded, extruded and die-cut parts. The book lists all types, dimensions and durometers of grommets, bumpers, bushings, suction cups, caps, cylinders, spring stock, packings, rods, rollers, sleeves, crutch tips, washers, extruded parts, laboratory stoppers, gaskets and miscellaneous parts. It also lists extrusions and die cut material meeting government specifications. Miller Products Co.

Circle No. 202 on Subscriber Service Card.

SUBMINIATURE RELAYS. Over 325 subminiature relays are described in the booklet just issued. The brochure contains photographs, diagrams, relay descriptions, contact and vibration ratings and other data. Radio Corporation of America.

Circle No. 211 on Subscriber Service Card.

COBALT REFERENCE LISTS. Three new reference lists, "Aluminum-Cobalt Alloys," "Cobalt in Cast Iron," and "Cobalt in Stainless Steel" are now available.

"Aluminum-Cobalt Alloys" contains references to literature published on cobalt in aluminum alloys from 1908 to mid-1957. This four-page bibliography also lists United States and foreign patents from 1897.

"Cobalt in Cast Iron" is a one-page list of literature references and patents from 1930 to 1956.

"Cobalt in Stainless Steel" contains one page of references to literature and patents from 1941 to 1957. Included are heat-resistant and high-creep-strength austenitic steels and alloys. Cobalt Information Center, Battelle Institute.

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